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ENVIRONMENTAL CONDITIONS RELATING TO HARMFUL INSECTS OF MAINLAND SOUTHEAST ASIA

by

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Geography Division

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FOREWORD

This report is designed primarily for non-specialists in entomological science who require a ready source of information on the disease-carrying insects and other arthropods of Southeast Asia and their ecological affinities. It shows, by graphic and tabular means, in what types of terrain a given species may be expected, considering such factors as vegetation, surface water, elevation, and human population density. Thus the hazard to troops and other personnel, requiring the use of special protective measures, can be estimated on a more local basis than the mere presence of a species within a country.

The information in this report is derived from secondary sources. Much of the basic information was compiled by Dr. B.V. Travis and his associates at Cornell University under a series of contracts sponsored by the Office of the Chief of Research and Development. Other open sources were also used, and the cooperation of the staffs of the National Medical Library at Bethesda, Maryland, the University of Maryland Library, and the University of Virginia Library is acknowledged with appreciation. Appreciation is also expressed to LTC J.E. Scanlon, Walter Reed Army Institute of Research; to Dr. Alan Stone, Agricultural Research Service, U.S. Department of Agriculture; to Dr. L.E. Rozeboom, Johns Hopkins University; and to Dr. Ralph A. Bram of the Southeast Asia Mosquito Project, Smithsonian Institution, all of whom offered helpful suggestions in the preparation of this report.

The author is Professor of Geography at Emory and Henry College, Emory, Virginia, and during preparation of this report was employed by the Earth Sciences Laboratory. The physiographic cross-sections were drawn by the author, and the other graphic material was prepared by the Cartography Office, Earth Sciences Laboratory, under the direction of Aubrey Greenwald, Jr. The research was conducted under Project 1T062109A129.

CONTENTS

LIST OF FIGURES

ABSTRACT

This study illustrates the relationships between physical and cultural environments and the presence of harmful insects and other arthropods in mainland Southeast Asia. These relationships are graphically portrayed in diagrammatic cross-sections through various parts of the study area. In addition, the physical and cultural factors that contribute to the propagation and spread of harmful insects are analyzed, and there are brief descriptions of the offending species.

Of the insects that contribute most to the origin and spread of disease, the mosquito easily takes first place. The hot, humid climate of Southeast Asia and the numerous water bodies provide ideal conditions for the survival of this group of insects. Various mosquito species are known to be transmitters of malaria, dengue fever, filariasis, and Japanese B encephalitis. Other important disease-causing insects include non-biting flies, fleas, sandflies, and lice, while disease-carrying species are also found among the mites and ticks. They are responsible for the spread of a wide variety of diseases and infections, including myiasis, plague, typhus, kala azar, yaws, and bacterial dysentery.

The principal environmental types in Southeast Asia are: (1) cities and large towns; (2) villages and isolated rural settlements; (3) ricefields; (4) brackish coastal margins; (5) delta plains, coastal plains, and floodplains; (6) elevated plains, low plateaus, and foothills; and (7) hills, mountains, and dissected plateaus. Each of these environments has its own complex of harmful insects. In general, the areas of lowest elevation, highest rainfall, and least population have the widest variety of harmful insects, and the areas of highest elevation, lowest rainfall, and densest population have the fewest. However, there are exceptions to this rule.

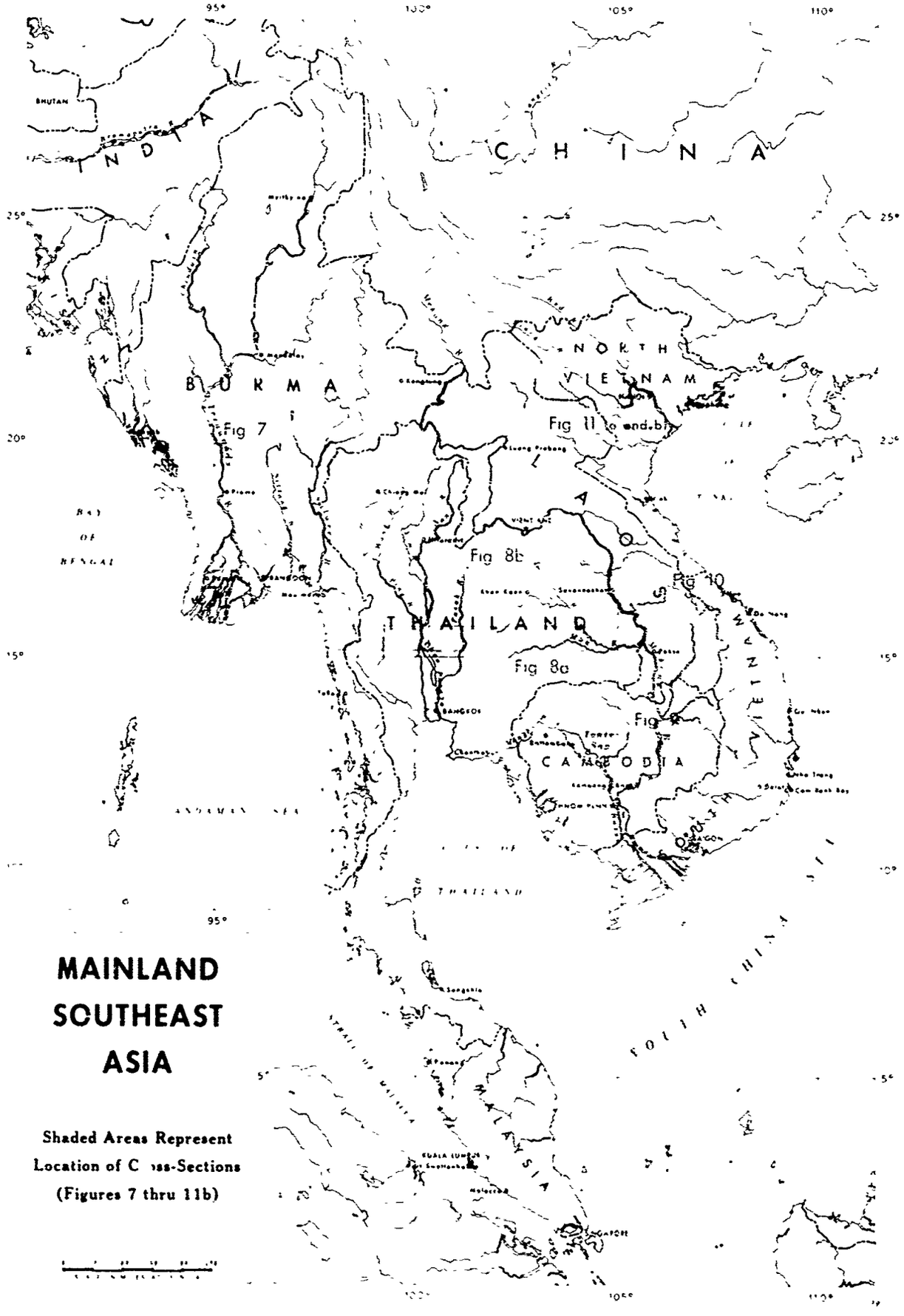

MAINLAND
SOUTHEAST
ASIA
Shaded Areas Represent
Location of C ss-Sections
(Figures 7 thru 11b)
INDIA
CHINA
BURMA
NORTH
VIETNAM
LAOS
THAILAND
CAMBODIA
Fig 7
Fig 8a
Fig 8b
Fig 10
Fig 11
BAY
OF
BENGAL
SOUTH CHINA SEA

Figure 1

ENVIRONMENTAL CONDITIONS RELATING TO HARMFUL INSECTS OF MAINLAND SOUTHEAST ASIA

1. Introduction

The distribution of harmful insects and other arthropods in Southeast Asia is influenced both by the natural environment and by cultural factors associated with the human population of the region. Climate is the most important physical element because of its direct effects on insect life and its strong relationships with natural vegetation and soil, which are also significant determinants of insect fauna. Landforms and land-water distribution are other physical factors that influence the pattern of insect life, both in terms of direct effects and their local modification of climate.

Numerous cultural factors also influence the distribution of harmful insects. Land-use patterns, rural settlements, urbanization, and population densities are reflected in ways that favor the development and spread of certain insects and retard or restrict development of others. The relative development of public and private sanitation, the state of medical technology, and the use of insecticides or other anti-insect measures also have bearing on the incidence of harmful insects.

2. Physical Environment

a. Terrain

The terrain pattern of mainland Southeast Asia has been aptly described as resembling a huge fan spreading southward from the eastern end of the Tibetan Upland. The ribs of the fan consist of mountain ranges, high and closely spaced in the north, somewhat lower and flaring outward in the south. The veins of the fan are formed by the deep valleys of the major rivers, the Irrawaddy, the Salween, the Mekong, the Red, and other lesser streams. As the valleys approach the sea they become wider and flatter. In their lower courses the valley floors are covered by alluvium from periodic floods, and the rivers are actively constructing deltas at their points of entry into the sea. This arrangement of mountain chains and valleys is the product of erosion and deposition by the major rivers of the area. These streams have cut the high ground into elongated sections and have built up the lower areas into their present alluvial plains.

The terrain of Southeast Asia is illustrated in Figure 2. In addition to the principal features of generally north-south-trending mountain ranges and river valleys, Southeast Asia has two major plateaus and a structural basin. The highest of the plateaus is the Shan Highland, a 20,000-square-mile upland between the Irrawaddy and Salween valleys in northeastern


SOUTHEAST ASIA
PHYSICAL REGIONS
Physiographs by Harry L. Hoo
MIRSIN-KUMON MOUNTAINS
CHIN-LETWA MOUNTAINS
SHAN HIGHLAND
TONKIN HIGHLAND
RED RIVER DELTA
GULF OF TONKIN
PEGU YOMA
ARAKAN YOMA
THAILAND HIGHLAND
IRRAWADDY LOWLAND
CENTRAL MENAM VALLEY
KORAT PLATEAU
ANNAMESE LOWLANDS
ANNAMESE HIGHLAND
BANGKOK
CAMBODIAN SAUCER
BILAUK TAUNG MOUNTAINS
KABAMOM MOUNTAINS
MEKONG LOWLAND
SAIGON
KRA PLAIN
KELANTAN-PAHANG HIGHLAND
MALAY LOWLAND
MALAY MOUNTAINS
KUALA LUMPUR
SINGAPORE

Figure 2

Burma. Elevations in this very rugged area range between 2800 and 5000 feet. Somewhat lower in elevation and slightly smaller is the Korat Plateau, a tableland with an average elevation of about 500 feet at its center, rising to about 2000 feet along its southern and western rims. The basin is referred to as the Cambodian Saucer, a gentle depression occupying the northwestern third of the Mekong Lowland and encompassing most of Cambodia.

A large, fresh-water lake, the Tonle Sap, covers the lowest part of the basin. One of the most unusual features of the physical geography of Southeast Asia is the yearly flooding of the Tonle Sap. The lake becomes considerably larger for several months each year because of the backing-up of flood waters from the Mekong River.

b. Climate

Most of Southeast Asia has a humid tropical climate, which is conducive to the development of a large and varied insect population. Temperatures are high throughout the year; there is no season of pronounced cold and consequently no need for insects to have a period of dormancy. Southeast Asia is dominated by monsoonal (or seasonally reversing) wind systems that cause most of the area to receive its maximum precipitation during summer. On the other hand, the winters are comparatively dry over much of the region. (However, local variations in position with respect to water bodies cause some places to experience their maximum rainfall in winter; for example, the central coast of Vietnam and the eastern coast of the Malay Peninsula.) Because of the monsoonal control of precipitation, seasons in Southeast Asia are customarily divided into the dry monsoon (winter for most of the region) and the wet monsoon (summer for most of the region).

In general, insect life is much more prolific during the wet monsoon than during the dry monsoon. The seasonal patterns of precipitation and the surface winds which govern these patterns are shown in Figures 3a and 3b.

During the dry monsoon, which usually prevails from mid-October to mid-March, air temperatures are comparatively cool and have fairly large diurnal variations (the difference between the high and low temperatures for a 24-hour period). Temperatures average several degrees lower in the north than in the south, but do not drop to the freezing level at any place other than the higher elevations. A typical lowland-interior station may have temperatures as low as 50-60°F during a January night, but the thermometer will likely rise to the 70's during the day. Except in certain exposed locations, precipitation is normally very light at this time of year.

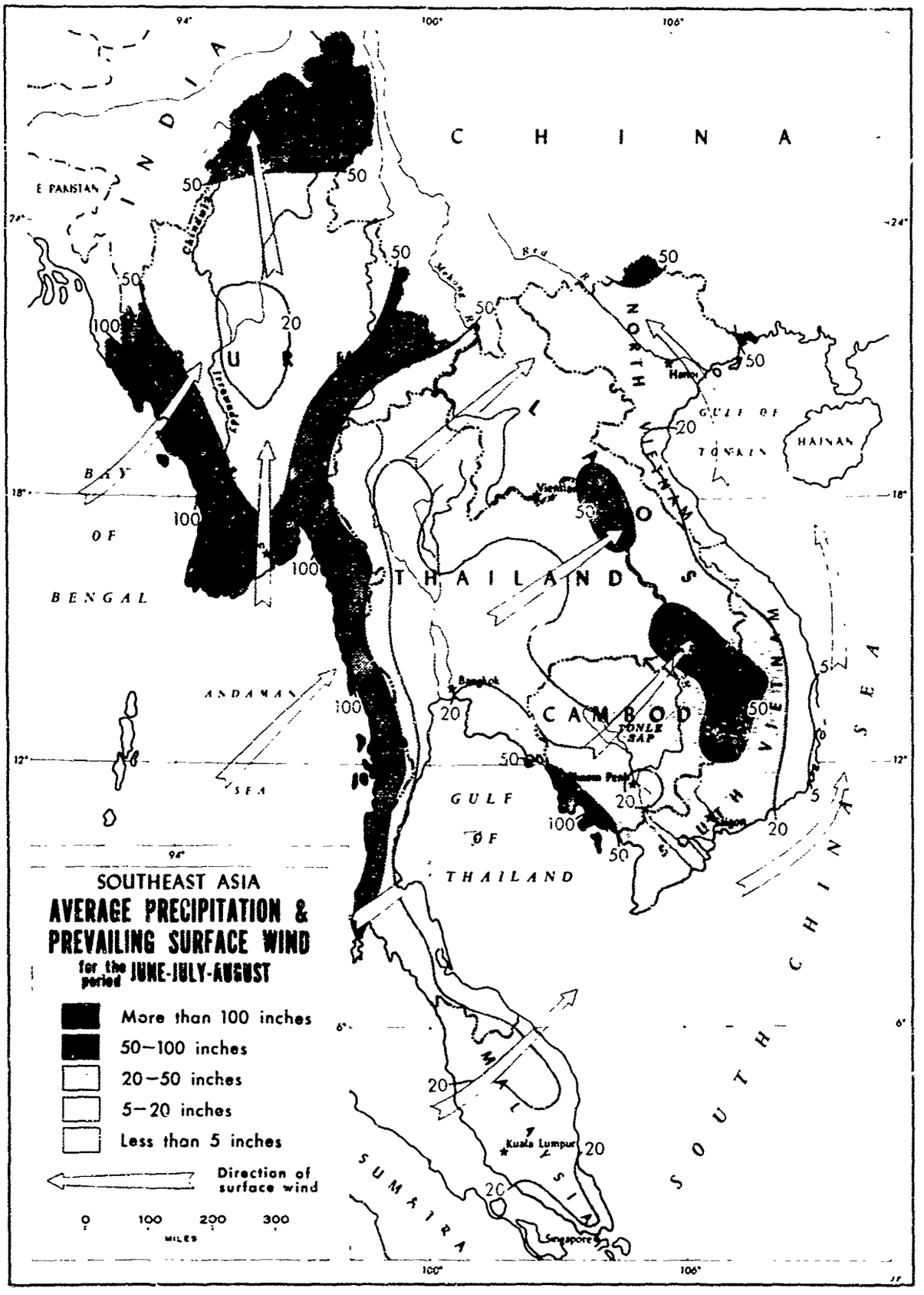

SOUTHEAST ASIA
AVERAGE PRECIPITATION & PREVAILING SURFACE WIND
for the period JUNE-JULY-AUGUST
More than 100 inches
50—100 inches
20—50 inches
5—20 inches
Less than 5 inches
Direction of surface wind
0 100 200 300
MILES
INDIA
CHINA
E PAKISTAN
BAY OF BENGAL
ANDAMAN SEA
THAILAND
CAMBODIA
LAOS
VIETNAM
GULF OF THAILAND
SOUTH CHINA SEA
MALAYSIA
SUMATRA
Bangkok
Vientiane
Hanoi
Saigon
Phnom Penh
Kuala Lumpur
Singapore
GULF OF TONKIN
HAINAN
TONLE SAP
Red R.
Irrawaddy
Salween
Mekong R.

Figure - 3a

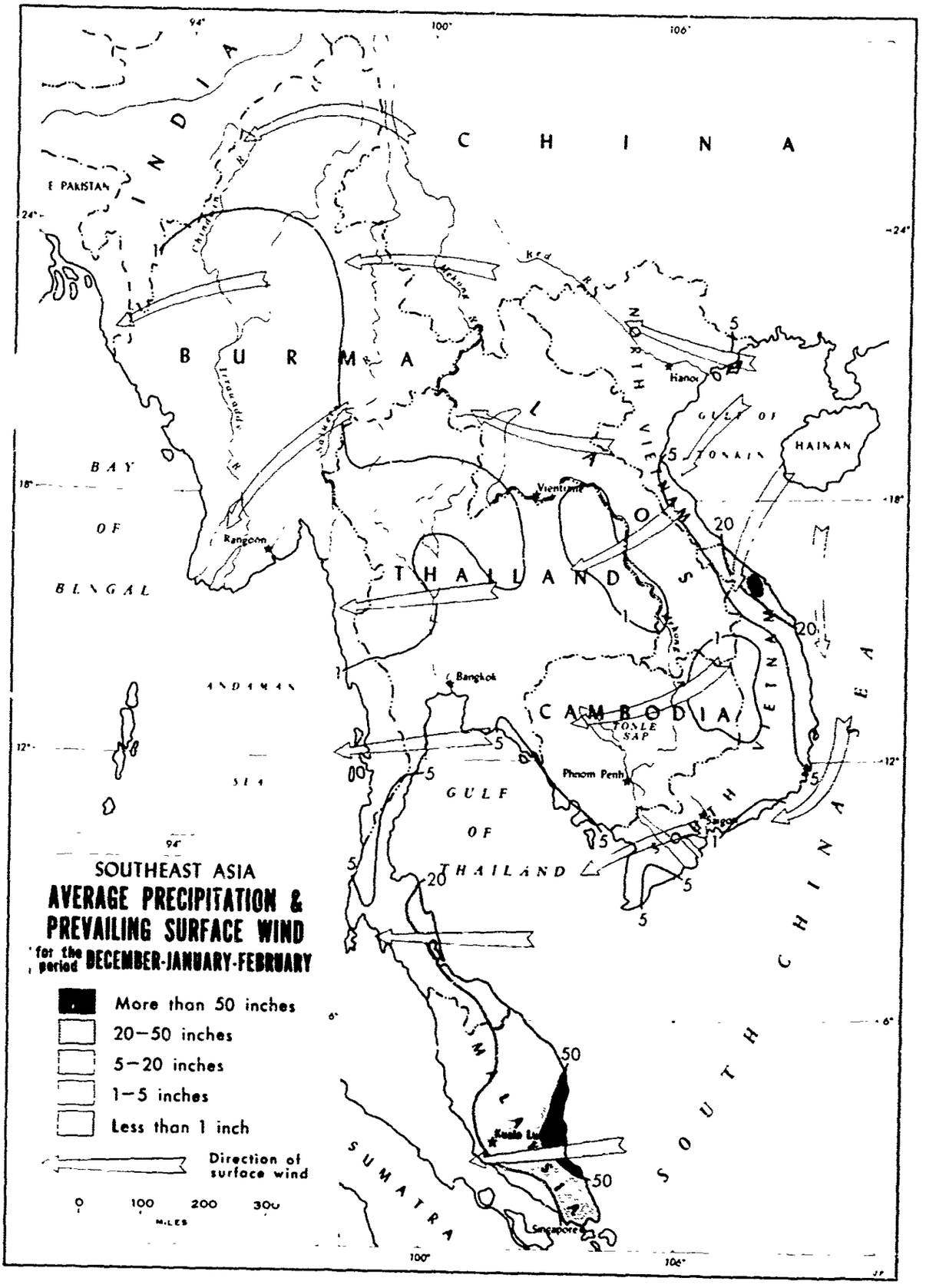

INDIA
E PAKISTAN
CHINA
BURMA
LAOS
THAILAND
CAMBODIA
VIETNAM
BAY OF BENGAL
ANDAMAN SEA
GULF OF THAILAND
SOUTH CHINA SEA
SUMATRA
Rangoon
Bangkok
Vientiane
Hanoi
Phnom Penh
Saigon
Singapore
HAINAN
TONLE SAP
SOUTHEAST ASIA
AVERAGE PRECIPITATION & PREVAILING SURFACE WIND
for the period DECEMBER-JANUARY-FEBRUARY
More than 50 inches
20–50 inches
5–20 inches
1–5 inches
Less than 1 inch
Direction of surface wind
0 100 200 300
MILES

Figure 3b

Where the land is exposed to moist southwest winds, the wet monsoon begins about the middle of May and persists until mid-September. Temperatures reach their yearly maximum just prior to the arrival of the rainy season, and, combined with increasing humidity, make the weather at this time of year exceedingly uncomfortable. With the increasing cloudiness accompanying the onset of the rainy season, air temperatures drop somewhat, but sensible temperatures and human discomfort remain high because of the very high humidity. Air temperatures are generally in the high 80's or low 90's (F°) during the day, and night-time temperatures drop only to the middle or upper 70's. These conditions are nearly perfect for the propagation of a wide variety of insects.

Summer rainfall is typically convectional (i.e., thunderstorms or heavy showers caused by heating of moist air), occurring most frequently in the mid-afternoon. However, convectional rainfall may also be triggered by factors other than daytime heating, so storm activity may occur at any time of night or day. Because of the prevalence of air movement from the southwest, the southern and western (windward) exposures have dense cloud cover and frequent heavy rains in summer. It is not unusual for a windward slope to receive well over 100 inches of rain during a single summer season. By contrast, the northern and eastern (leeward) slopes are much drier, often with no more than 20 inches of rain during the same period. The windward-leeward differences are particularly noticeable along the Arakan Yoma, the Annamese Highland, and the mountainous Malay Peninsula (see Figure 2).

Temperatures during the summer monsoon are not extreme, afternoon highs reaching the high 80's or low 90's and nighttime minimums dropping to the middle to upper 70's. This is due to the very humid condition of the air along with the attendant heavy cloud cover. Consequently, the highest temperatures are recorded during the mid-spring period preceding the beginning of the rainy season. Temperatures are highest at the lower elevations and become progressively cooler with increased elevation. The temperature may be expected to drop slightly more than 3 Fahrenheit degrees for every 1000 feet rise in elevation.

c. Vegetation

Southeast Asia, an important home of man for more than 3000 years, can nowhere be described as having a "natural" vegetation cover. For throughout this long period of occupation, man has been clearing forests, burning grasslands, and replacing the natural growth with that of his own choosing, so that today no aspect of the landscape can be described as completely unaltered by man. Almost every so-called "natural" vegetative association is secondary growth with probably no more than 50 percent of the original species still present. In some places the effect of man has

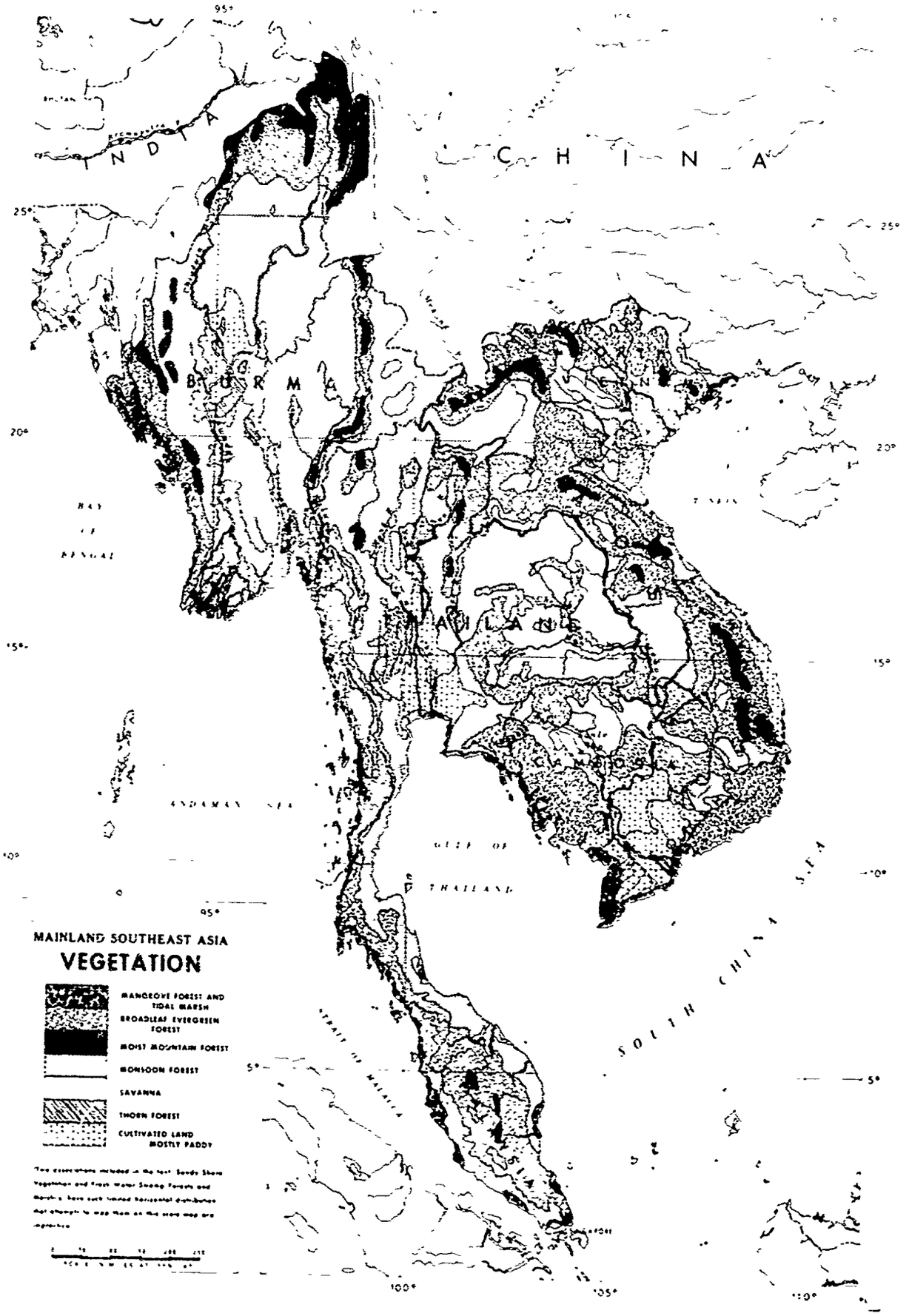

INDIA
CHINA
BURMA
THAILAND
CAMBODIA
BAY OF BENGAL
ANDAMAN SEA
GULF OF THAILAND
SOUTH CHINA SEA
MAINLAND SOUTHEAST ASIA
VEGETATION
MANGROVE FOREST AND TIDAL MARSH
BROADLEAF EVERGREEN FOREST
MOIST MOUNTAIN FOREST
MONSOON FOREST
SAVANNA
THORN FOREST
CULTIVATED LAND MOSTLY PADDY

Figure - 4

been to increase the cover of tall grasses, particularly where there are fairly pronounced periods of drought. Elsewhere bamboo jungles may become the dominant surface cover.

Under the influence of the monsoonal climate, the character of the vegetation varies according to the length of the dry season and the total annual rainfall. In sections where there is no long dry season and annual rainfall averages over 80 inches, broadleaf evergreen forest is dominant. Where the annual rainfall drops below 80 inches and there is a well-defined dry season, monsoon forest replaces the evergreen forest. Where rainfall is less than 40 inches, the monsoon forest gives way to scrub forest.

The dominant natural vegetation types of Southeast Asia, therefore, are broadleaf evergreen forest and monsoon forest. However, there are several other types which may or may not fit within these broad categories, but which are important for the purposes of this study. Therefore, the grouping used here is as follows: (1) mangrove forests; (2) sandy-shore vegetation; (3) broadleaf evergreen forests; (4) moist mountain forests; (5) monsoon forests; (6) savannas; (7) thorn forests; (8) fresh-water swamp forests and marshes; and (9) man-made or man-dominated associations. The distribution of these vegetational types, with the exception of sandy-shore vegetation and fresh-water swamp forests which are of relatively small extent, is illustrated in Figure 4.

(1) Mangrove forest. The mangrove forests, a specialized adaptation of the broadleaf evergreen, consist of a number of species which grow only along coasts where active sedimentation is taking place. Most of these species have pneumatophores or "breathing roots" which project above the ground level in loops or "knees". All have structural adaptations which permit them to root effectively in unstable mud, and the extensive root systems, often beginning well above the ground like flying buttresses, may provide support for large trees. The chief difference between species lies in the amount of tidal inundation they can tolerate; consequently, there is a well-defined zonation of species parallel to the shore line. The seaward plants, being most tolerant of salt water, make up the advance guard pushing seaward. At the inland fringe, the least salt-tolerant trees mark the transition to fresh water swamp forest or some other non-marine type of vegetation.

(2) Sandy shore vegetation. Along the sandy shores of Southeast Asia is a type of vegetation termed the Pes-caprae formation. This corresponds generally to the strand vegetation of Europe and North America, and consists of salt-tolerant short herbs, grasses and shrubs. It may form a complete ground cover, but more frequently it consists of an open community of plants.

Along the moister tropical beach margins, the herbaceous vegetation abruptly gives way to beach woodland, which may form either a dense belt of fairly large trees or scattered clumps of trees separated by open space. The trees usually begin no more than 75 to 100 yards inland from the shore and are distinct from those found in other forests. Some trees of this forest reach heights of 90 feet or more, nearly as high as the average tree in the tropical rainforest. Undergrowth is dense, and combined with an abundance of lianas and epiphytes, it makes penetration difficult.

(3) Broadleaf evergreen forest. The broadleaf evergreen forest of Southeast Asia is located on the poleward margins of the tropical rainforest, and differs from it by having a greater proportion of deciduous trees. Typically, there are three stories of trees in addition to the shrub and herb layers. Trees 150 to 200 feet tall are scattered throughout the forest, their isolated crowns rising above the second level of more solid green. These taller trees shed their leaves annually but appear to be evergreen because many of the species grow new leaves before the old ones have dropped off. Trees of this story have thin, straight trunks despite their great height, and they are inclined toward flattened crowns. Many of the tall trees have widely spreading plank buttresses supplementing the root anchorage.

The middle story, reaching a uniform level at about 60 feet, consists almost entirely of evergreens. The trees are smaller in every respect except for the leaves, which are larger than those of the upper level. Palms and bamboos form part of the undergrowth. The herbaceous layer is sparse, consisting chiefly of ferns and dicotyledonous herbs, but never grasses. Conspicuous also are climbing plants, often with lengths greater than 300 feet, They consist of lianas which climb from the ground to the sunlit crowns, using the trees as supports only, and epiphytes, which include orchids, ferns, and wild figs.

The broadleaf evergreen forest is found chiefly in areas of heavy rainfall along the southern coastal margins, particularly in lower Burma and in the southern Annamese Highland, where the heaviest rainfall totals are recorded. Figure 5, a profile of vegetation from the zone of tropical rainforest through the zone of scrub forest, illustrates the relative position of the broadleaf evergreen forest.

(4) Moist mountain forest. Above 2500 feet throughout most of Southeast Asia, the broadleaf evergreen forest gradually gives way to temperate-zone trees such as oak and chestnut. The canopy is more open than in the broadleaf evergreen forest. Ground herbs and ferns are more abundant, herbaceous plants often forming a thick ground carpet. Climbing plants are still abundant, particularly epiphytes, which appear to increase with elevation.

Forest profile from humid evergreen forest to semi-arid thorn forest, typical of change from windward exposure of Arakan Yoma in western Burma to the Central Irawaddy Valley. (After Richards – Tropical Rainforest)

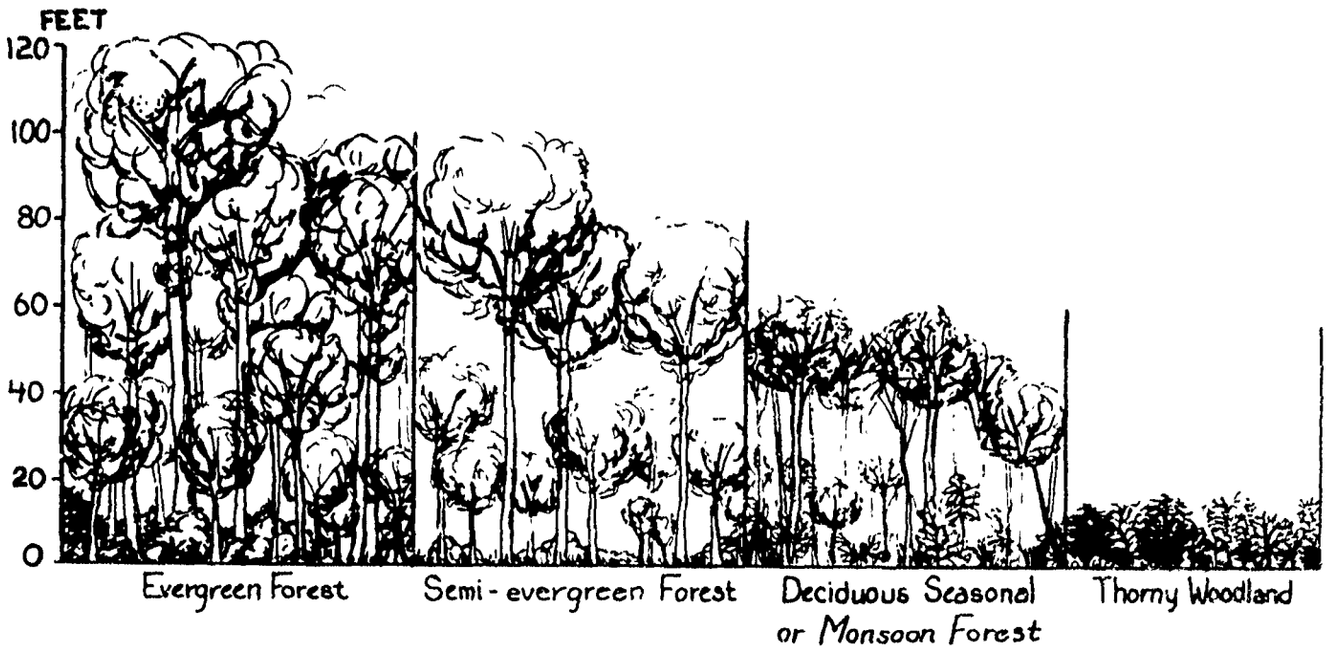


Figure 5

At still higher elevations plants become progressively smaller, and the woody species are often twisted and gnarled. Above 5000 feet there may be a moss forest which differs considerably from either of the other moist types. Here the number of tree stories is reduced to one, the average height ranging between 20 and 30 feet. The thick cover of epiphytes (chiefly mosses and liverworts) gives a grotesque appearance to the dwarfed trees and to the forest in general. Mosses hang in thick blankets everywhere, often burying small trees and shrubs. Moss forests will not grow where there is a pronounced dry season. In typical monsoon areas, pine forests intermixed with some broadleaf trees occupy the zone above 5000 feet.

(5) Monsoon forest. Monsoon forest is the most widely distributed of the natural vegetation types in Southeast Asia. It is transitional between the wet rainforest and the dry subtropical savannas. There are fewer species than in the rainforest, teak being the most widespread although it seldom constitutes more than 10 percent of the total forest stand. Where rainfall is relatively high, the trees are dormant for only a brief period, often putting forth new growth only 3 or 4 months after the time of leaf fall. The shrub layer is poorly developed, but bamboo is abundant. Grass cover on the ground is unusual, and there are few ferns. Climbing plants are conspicuous, but they do not alter the open appearance of the forest.

Under less humid conditions (which are characteristic of a large part of the area), teak forest dominates. Teak is adapted to a more prolonged period of drought, and usually occurs where the rainfall ranges from 40 to 60 inches. It often is found in pure stands as a result of forest burning, because its saplings can survive fire without destruction and its thick, hard-cased seeds are also very fire resistant. It is a large tree growing to heights of 120 feet, and pure stands constitute an important resource because teak finds a ready market as a cabinet wood.

Bamboo, a giant perennial grass, is another characteristic plant of the monsoon forest, particularly the drier portion of it. Large trees are completely covered with bamboo, for, as in the case of teak, bamboo seeds are fire-resistant.

In the still drier margins of the monsoon forest, a type of forest referred to as indiang in Burma and padeng in Thailand occurs. This forest develops in areas where the average annual rainfall is about 40 to 45 inches. Trees are small, ranging between 30 and 80 feet in height. The undergrowth consists largely of a tangle of grasses with occasional cycads. Bamboo often is scarce or missing. The surface flora is scanty, and bare soil is common. Epiphytes are usually abundant.

(6) Savanna. In Southeast Asia open grasslands are generally secondary growths arising after the destruction of the monsoon forest by

burning or shifting cultivation. As is true in many savanna areas, it is a common practice to set fire to the coarse dry grass at the end of the dry season to promote the growth of the young tender shoots that are preferred for grazing. Typically, savannas have scattered, widely spaced trees which lose their leaves during the dry season.

(7) Thorn forest. On the drier margins of the savanna forest the tree growth is mostly thorny. Acacias are the most common, occurring as both trees and bushes. They seldom grow more than 30 feet tall. As in the savannas, grass is the dominant undergrowth and tree climbers are abundant.

Thorn forests occur where the rainfall is less than 40 inches per year, with local variations caused about as much by soil differences as by rainfall. The depth and porosity of the soil substantially modify the effects of rainfall. The farther away from the humid rainforest, the more marked is the effect of soil differences on vegetation. The broadleaf evergreen forest and the moister sections of the monsoon forest are essentially unaffected by the character of the soil.

(8) Fresh water swamp forest and marsh. In many places where land and water meet, the land constantly encroaches on the water. Among the more important agents in this encroachment is vegetation, which impedes the movement of water and thus increases deposition of material carried in suspension.

The primary vegetative succession in fresh water lakes and swamps begins with floating aquatic plants associated with water lilies. These may give way to a swamp sedge and fern community made up of various ferns, sedges, grasses, and other herbaceous plants. These are succeeded by taller plants including reeds, rushes, and ferns. The next stage consists of shrubs and palms, which may be followed by a tall, fresh-water swamp forest.

Marshes are widespread in the deltas and flood plain margins of the larger streams. Seasonally inundated marsh land forms a belt many miles wide around the Tonle Sap in Cambodia.

(9) Man-made or man-dominated patterns. While man has profoundly altered the natural pattern of vegetation in Southeast Asia, the centers of dense human population show the greatest impact. In addition to their usual domesticated plants, densely populated areas have numerous non-cultivated varieties which show, by means of their patterns of distribution and the use made of them, the pervasive influence of man. Various types of trees serve as sources of lumber, firewood, and fruits and nuts. Certain species may be nurtured as ornamentals or shade trees; wild grasses serve as forage for domesticated animals; and numerous wild flowering plants are gathered and used for decoration.

The most important field crop and the one with the greatest effect on the landscape wherever it is found is wet rice. This crop dominates all river deltas as well as most of the flood plains adjacent to the larger streams. Wet rice demands a uniform but very gently inclined surface, permitting controlled flooding during the period of growth (the 5-month period coinciding with the wet monsoon).

In many deltas farmers have the problem of not only providing adequate water for their rice plants, but also of protecting their fields from flooding during the periods of heavy rain. Natural and man-made levees hold back streams which even at normal levels are flowing well above the agricultural land on either side.

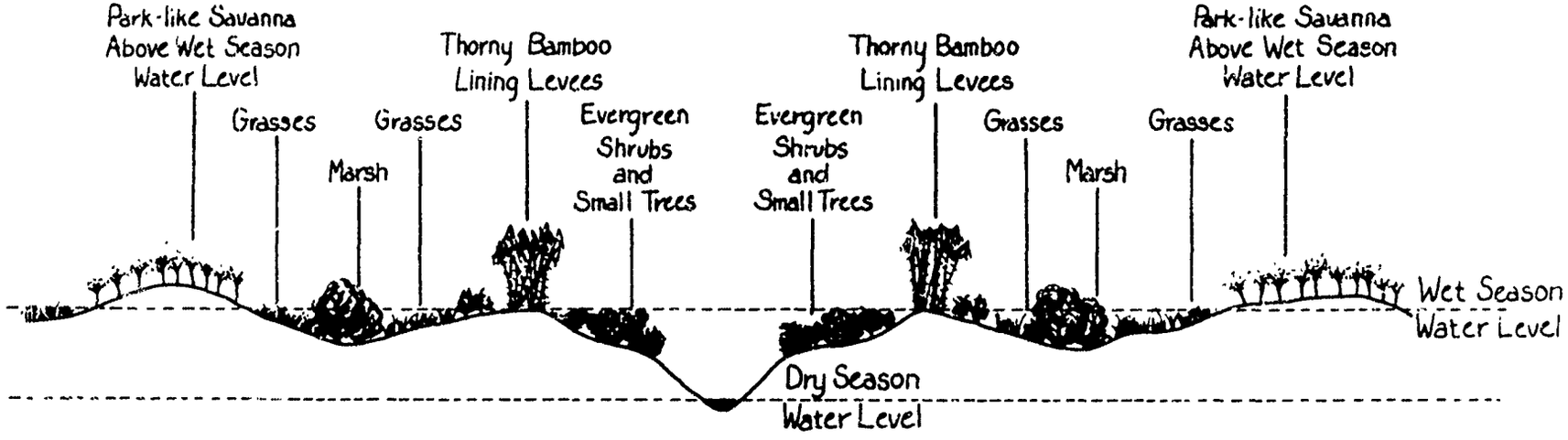
In most of the low-lying delta lands two crops of rice may be planted in a single year, and in the better drained portions dry crops (corn, sweet potatoes, etc.) are frequently planted after the rice crop is harvested. Every agricultural household produces a variety of garden vegetables, and surrounding every homestead and paralleling every village street are fruit trees, palms, ornamental shrubs, and shade trees.

Under less humid conditions, wet rice fields occupy only a small part of the total land area, mixed farming being more characteristic. Field crops include peanuts, sesame, beans, cotton, millet, and an unirrigated variety of rice called dry rice.

The hills and mountains are sparsely populated, and in many areas "shifting" agriculture still goes on. Domestic tree crops are important, including tung trees, tea shrubs, and, in certain parts of the south, rubber and coconut plantations.

d. Ground Conditions.

While it is difficult to generalize relative to ground conditions over so large and varied an area as Southeast Asia, it is important to recognize the influence they have over the distribution of the various forms of insect life. Surface moisture is essential to the breeding of many insects, and moisture conditions often determine what species will be found in a given locality. This is particularly true of mosquitoes, but it is also true of most of the other insects. Moisture, either in the form of transient surface water or ground water, is usually necessary for their existence. Ground cover is also important to most insects, either directly or indirectly, providing food and harborage for their vertebrate hosts (rats, mice, shrews, birds, etc.), or refuge for the insects themselves. The composition of surface materials affects distributions indirectly through its adaptability to the needs of burrowing animals, both vertebrate and invertebrate. Some of the relationships between environmental factors and ground cover are illustrated in Figure 6, a cross-section of a stream valley in the Korat Plateau.



Vegetational Cross-section through river valley in the Korat showing backwater swamp development behind the natural levees. (After Dobby – Southeast Asia)

Figure 6

Several factors influence ground conditions in Southeast Asia. All lowland areas are generally flooded during the wet monsoon. Major streams passing through broad flood plains develop natural levees which maintain stream channels at higher levels than the adjacent land. Thus after flooding has occurred it is impossible to drain the excess water from this low-lying land into the main streams. Consequently, the levees are generally paralleled by fresh-water swamps and marshes (similar to the bayous of the Lower Mississippi Valley) away from the main streams. This is true not only of the major lowlands, but, because of the tremendous seasonal flood crests, it is also true of the streams crossing the Korat Plateau. Most of the land adjacent to these streams dries out rather quickly after the beginning of the dry season, but the lower-lying deltas generally remain soggy most of the year.

Tidal marshes and mangrove forests are common along the coast, particularly where delta formation is in progress. These are affected by both flood water inundation and by the penetration of tidewaters, which during the flood crests greatly expand the area covered by water. Extensive lowlands are water-logged for part of the year because of the intensive cultivation of rice. Beneath the rainforest, the ground is generally covered with a thin, spongy leaf litter. This organic layer becomes progressively thicker from the rainforest into the savanna.

3. Harmful Arthropods

a. General

There are numerous species of harmful insects and other arthropods in Southeast Asia, many of which adversely affect man in an indirect way, destroying his field crops, infesting his fruit trees, contaminating his stored food, feeding on his clothing and other household fabrics, attacking his livestock and domestic pets, and even eating away the foundations of his buildings. However, the primary concern of this study is the distribution of insects which can cause direct bodily harm to military personnel in the area, and the environmental conditions under which these insects exist. In particular, emphasis is directed toward those species responsible for the spread of disease and infection. Tables I, II, III, and IV provide a listing of the various harmful arthropods of the regions, including more detailed information for each species than is given in the text. (See Appendix).

b. Mosquitoes

By far the most annoying insect throughout the region and the most effective disease carrier is the mosquito. Individual species are found in almost every environment, from the coastal margins to elevations above 8000 feet. The one essential element for all is the presence of water,

regardless of its physical qualities. Some mosquitoes breed only in clean, flowing water, and others in stagnant waters fouled by decaying vegetable matter; some are adapted to the brackish water of the coastal margins, and others seem to thrive only in the cool, fresh waters of upland streams. Poorly drained areas such as the flood plains of the larger rivers, and interior and coastal marshes, are particularly favored. Fish ponds, rice paddies, shallow wells, borrow pits, and other man-made reservoirs often prove attractive sites for breeding. Permanent lakes and even free-flowing streams seem to be favored by some species. Open water, free of vegetation, is least favored.

Though generalizations concerning environmental controls are difficult when dealing with a group as large as the mosquito family, there are a number which appear valid. Water temperatures are important. Above 80°F the number of species decreases, and water temperatures in excess of 95°F usually are fatal to larvae. Many mosquitoes escape excessive heat by occupying moving water, such as that found along the margins of flowing streams. Few are active when air temperatures are warm to hot and relative humidities are low. Most remain relatively close to breeding sites throughout their existence, with major movements generally limited to less than one mile.

In terms of human health, the more important genera are Anopheles, Aedes, Mansonia, and Culex. Anopheles, the largest genus, is also of greatest significance in the spread of disease. It is chiefly noted as a vector (carrier) of malaria, though certain species are also involved in the spread of filariasis. While generally described as lowland mosquitoes, Anopheles are found at all elevations up to 8000 feet, and are actually more effective in the transmission of malaria at the higher elevations because of the greater tendency for the upland species to feed on man rather than other animals. Aedes are carriers of yellow fever in other parts of the world; although this disease is unknown in Southeast Asia, if a reservoir host were to be found it could be introduced. In Southeast Asia the principal role played by Aedes is as a transmitter of dengue fever and, more rarely, of Japanese B encephalitis. It is also a possible carrier of the principal Southeast Asian forms of filariasis, Wuchereria bancrofti and Wuchereria malayi. Mansonia mosquitoes are the more important carriers of filariasis, particularly Wuchereria malayi. Culex are the principal infectors of Japanese B encephalitis.

c. Non-biting Flies

As a pest and disease vector, the non-biting fly probably is outranked only by the mosquito. A number of these flies, notably Chrysomyia bezziana, are involved in myiasis infections. Myiasis may be caused by flies laying their eggs or depositing their larvae in or near diseased tissue of man or animals. In some cases larvae are found only on the

diseased tissue; however, more serious myiasis results from larvae that invade the deeper tissues. Any open wound or even bruised tissue may attract flies seeking to deposit eggs. The more vulnerable areas include the eyes, nose, ears, and the anal and genital areas. Intestinal myiasis may develop upon eating meat in which eggs or larvae have been deposited. Musca sorbens, a close relative of the common house fly, may be an important agent in infections of yaws, and others may serve as mechanical carriers of bacterial dysentery. Non-biting flies are found in almost every type of environment, being directly related to man or his domestic animals.

d. Fleas

Fleas are important as pests and disease carriers. All are parasitic on vertebrate hosts, especially on rats and mice. These rodents and their flea parasites tend to follow the major communications lines, and are particularly numerous in warehouses and storage areas. Especially attractive are grain stores, abandoned feed dumps, and garbage disposal areas. In residential districts in cities and towns, they are more numerous whenever there is unusual crowding. Fleas are most directly associated with the spread of plague: Xenopsylla cheopis is considered to be the principal vector of bubonic plague, and Nosopsyllus fasciatus, a carrier of murine typhus, is probably the most important agent causing plague infestation among wild animals.

e. Sandflies

Sandflies are pests throughout Southeast Asia. They are capable of inflicting painful bites, and are involved in the transmission of kala azar. Only one, Phlebotomus argentipes, is considered a highly infectious carrier in this area. Sandflies appear to be capable of breeding almost anywhere they can find unprotected soil rich in organic matter, usually within short distances of houses and barns. Reservoir hosts are mostly dogs and rodents. Sandflies are sensitive to strong winds, bright sun, and even full daylight.

f. Lice

Lice do not constitute a serious threat to man in most parts of Southeast Asia, because they tend to thrive only where cool conditions prevail and where an abundance of clothing is worn. Nevertheless, head, pubic, and body lice do occur in Southeast Asia. Occasionally, body lice (Pediculus humanus corporis) may be involved in the transmission of disease. Lice thrive under conditions of poverty, overcrowding, and the associated lack of cleanliness. They are responsible for the spread of epidemic typhus, the most serious form of disease, of which man is the only reservoir host.

g. Mites

Mites, like the disease-carrying fleas, are oriented chiefly toward major infestations of rats and mice, even though other animals, such as tree shrews, squirrels, birds, and man serve as alternate hosts. Mites are responsible for the spread of scrub typhus (Tsutsugamushi disease), murine typhus, and other rickettsial fevers. The incidence of mite-borne diseases is directly dependent upon the affinity of the natural hosts to man. As man provides harborage for rodents the incidence increases.

A high incidence of mites is found both in the tall savanna grasslands and in dense forests. Trombicula deliensis, probably the most important agent involved in the transmission of scrub typhus, is more common in forests while the other important carrier, Trombicula akamushi, is more often found in scrub forest or grassland. The preferred hosts for both are wild (field) rats, which account for their primarily rural occurrence. The heaviest concentrations are found in and near abandoned food dumps, gardens, and neglected plantations. The more serious outbreaks of typhus generally are related to drought, floods, crop failures with associated famine, poor sanitation, and the destruction wrought by military operations. Mites are sensitive to changes in humidity, and in most cases the incidence of typhus is lower in the dry season.

h. Ticks

Ticks, like lice, may be involved in the transmission of typhus and other rickettsial fevers. There are two species of ticks common to this area which may act as disease transmitters. Rhipicephalus sanguineus, the common brown dog tick, is chiefly found in or near human settlements because of the close association between dog and man. It is responsible for tick-borne typhus, Indian tick typhus, and other rickettsial fevers. Haemaphysalis spinigera is more commonly found in dense evergreen forests with thick undergrowth and an annual rainfall of more than 80 inches; it is responsible for the transmission of Kyasanur forest disease. Both species deposit their eggs on the ground, and both the larvae and the adult ticks attach themselves to whatever host is available, be it monkey, rat, dog, man, or other animal. Men resting directly on the ground are likely to pick up both ticks and their larvae, thus becoming accidental hosts.

i. Other Arthropods

There are a number of insects and other arthropods whose bites and stings are responsible for skin inflammations. These include numerous flies, midges, spiders, centipedes, bedbugs, and many others. While such bites and stings are seldom disabling by themselves, they may easily lead to serious skin infections. Common to the Tonkin Basin and northern Laos

are Paederus beetles, whose body fluids when crushed against the skin may cause painful blisters.

4. Cultural Environments and Associated Harmful Arthropods

Throughout Southeast Asia, regardless of the physical surroundings, there are large numbers of harmful insects whose distribution tends to be closely related to human population concentrations. These include disease-carrying flies; head, pubic, and body lice; bedbugs; rat-infesting fleas and mites; and an abundance of domestic mosquitoes.

a. Cities and Large Towns

Urban centers, though generally less bothered by harmful insects than rural settings, are, nevertheless, infested by a number of disease-carrying arthropods. Probably the most dangerous of these are the species parasitic on rats and mice. These include fleas which are responsible for outbreaks of plague, and mites associated with epicemics of typhus. Heaviest infestations of rodents and their parasitic guests are found in and around port facilities, railroad depots, warehouses and storage centers, and densely crowded residential districts. Non-biting flies are everywhere, particularly around stables, open food markets, and occupied houses, and they are especially abundant during the rainy season. The so-called domestic mosquitoes are numerous wherever there are uncontrolled breeding sites. Perhaps the most important of these is the dengue fever carrier, Aedes aegypti. However, species capable of transmitting malaria, filariasis, and Japanese B encephalitis are also found. Although mosquitoes common to the larger cities are generally among the less infectious carriers of malaria, serious outbreaks do occur from time to time. Body lice, responsible for occasional outbreaks of typhus, may find favorable conditions in the crowded slums of urban centers, particularly during the cooler part of the year.

b. Villages and Isolated Rural Settlements

Harmful insects found in villages and rural settlements are generally those of the surrounding country. However, the mere presence of man may alter drastically the distributions that might be expected in the completely natural state. Mosquitoes are particularly abundant around the smaller human clusters and include both the primarily domestic species as well as species which feed indiscriminantly on man or cattle. Cattle sheds located between breeding grounds and human habitations may serve as effective barriers; for this method to be effective, houses should be located at least 200 yards from the cattle sheds. Non-biting flies are greater pests in the more rural setting than in towns and cities, due to the fact that many are attracted to cattle and other livestock as well as to man. This is true of many of the natural vectors of myiasis, yaws, and bacterial dysentery. Sandflies are numerous in village and rural

homesteads, because their favorite breeding grounds are on bare ground contaminated with decaying organic matter such as is found in the vicinity of houses and cattle sheds. One species, observed in the former French territory of Indochina and likely found in other areas, is a vector for kala azar.

Human settlements, whether rural or urban, generally attract numerous rats and mice, and the parasitic insects associated with them. Of particular significance in rural settlements are the Trombiculid mites responsible for the spread of scrub typhus. This is because their rodent hosts are principally wild rats, which are seldom found in or around cities but commonly infest rural areas where man has been. An unusually high incidence is associated with tall savanna grass, and recent findings indicate that heavily forested areas are also amply endowed with this pest. Mites are far more numerous in the surface litter than on growing vegetation, and men sprawling on the ground during rest are likely to have their clothing infested. While the incidence of plague is generally lower in rural than in urban environments, plague-carrying fleas such as Xenopsylla cheopis are common. Ticks are numerous in all parts of Southeast Asia, but they are most abundant in rural areas. Lice are common everywhere.

c. Ricefields

Extensive portions of Southeast Asia are used for cultivation of rice. Although a variety of arthropods, including gnats, midges, all kinds of flies, fleas, mites, and ticks, are common, mosquitoes are the most serious threat to the health of man. Among the myriads of mosquito species there are several which are disease vectors, and a number of these are confined, for the most part, to the ricefields. These include Anopheles sinensis, a malaria carrier of some importance in both Burma and Vietnam and a possible vector of filariasis, and a number of Culex species capable of transmitting Japanese B encephalitis. Also abundant in the ricefields of Southeast Asia are Paederus beetles, whose body fluids may cause blisters if the insect is crushed on the skin. These become a problem during the months of May and September when they are most likely to enter houses.

5. Natural Environments and Associated Harmful Arthropods

a. Brackish Coastal Margins

Although the number of individuals of a single species tends to be large, the number of species adapted to the brackish coastal margins is limited. Mosquitoes are probably more numerous than any other insect group, and the individual species adapted to this environment include important malaria carriers such as Anopheles sundaicus and Anopheles umbrosus, the most important dengue fever carrier, Aedes aegypti, and, less frequently, filariasis carriers of the genus Mansonia. Gnats and midges are numerous,

and those insects parasitic on man, such as fleas and lice, may become problems if preventive measures are not taken by individual personnel.

b. Delta Plains, Coastal Plains, and Flood Plains

Practically all genera of harmful arthropods are found somewhere within these low-lying areas. Mosquitoes are abundant everywhere, but the incidence of malaria is lower than at higher elevations. This is because the more abundant Anopheles malaria carrier in the lowlands tend to be zoophilic (i.e., preferring animals) in their blood feeding. Mosquitoes capable of transmitting both filariasis and Japanese B encephalitis are found in most low areas. Mansonia species, considered to be chiefly responsible for the Wuchereria malayi variety of filariasis, are more widespread in swamp forests and marshes. Flies and fly-borne diseases such as myiasis, yaws, and bacterial dysentery are ubiquitous in areas occupied by man. Trombiculid mites, responsible for scrub typhus, are more numerous in rural lowlands than anywhere else in Southeast Asia. They often reach epidemic stages during military operations. The spread of typhus infections tends to follow drainage lines. Rat fleas, which are carriers of plague, are also most numerous in lowlands, especially in or near cities. Non-biting flies, biting flies, ticks, lice, and other pests are found in most lowlands. The land leech, a blood-sucking worm of widespread occurrence, particularly prevalent in the rainforest, is a pest perhaps more feared than any of the insects. In marshes or swamps, the water leech may constitute a similar problem. Though not extraordinarily painful, the bite of the leech bleeds profusely, and secondary infections associated with it may be disabling.

Subhumid localities, as in central Burma, have a less varied insect fauna than humid areas. The genera tend to show adaptations to the more arid conditions: most are nocturnal, and many have heavy waxy external coatings which help to prevent loss of body fluids. Mosquitoes are far less numerous in arid places because of their tendency toward excessive loss of body moisture through respiration, and those found in such environments are most active during the early morning hours when temperatures are low. Incidence of disease caused by Trombiculid mites is reduced under arid conditions and is markedly lower during the dry season. Biting and non-biting flies are fairly numerous, as are ticks, spiders, and scorpions.

Tall savanna grasslands have the greatest abundance and variety of insects during the wet season. Rodents serving as hosts for disease-carrying insects find good harborage in such areas. Trombicula deliensis, the chief vector for scrub typhus, is particularly abundant here. Mosquitoes are most numerous in the savanna during the rainy season.

c. Elevated Plains, Low Plateaus, and Foothills

The chief distinction between the harmful insects found here and those of the lowlands is largely in terms of mosquitoes. The more common

species found in these areas of intermediate elevation include some of the more virulent malaria carriers in Southeast Asia, such as Anopheles minimus and A. leyporiensis candidiensis. Both are abundant in foothills, and both favor the cool water of slow-moving permanent streams.

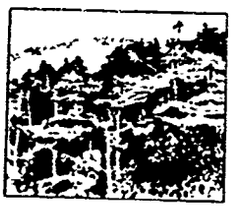
d. Hills, Mountains, and Dissected Plateaus.

The variety of harmful insects in the upland areas and their patterns of distribution are limited largely by exposure and elevation. In general, both the number of species and the total number of individuals tend to decrease with increased elevation and from the more humid windward exposures toward the drier leeward sides. Mosquitoes, though less numerous than elsewhere, are found as high as 8000 feet, and include species known to be vectors of malaria, filariasis, and dengue fever. Most mountain mosquitoes are adapted to the fresh, moving water of permanent upland streams. Typhus-carrying Trombiculid mites have been observed at elevations up to 8,000 feet, with infections reported up to 7,000 feet. They are particularly abundant in the northern uplands of Burma. Plague-carrying rat fleas are also found in the uplands, usually in conjunction with the presence of man. Nosopsyllus fasciatus, a possible vector of murine typhus, is particularly well adapted to the relatively cool conditions of the uplands.

Figures 7-11 show association of terrain and vegetation patterns with harmful insects.

LEGEND

MANGROVE FOREST



DRY SHRUB AND THORNY SCRUB

MARSH

MONSOON FOREST

SAVANNA

MOIST EVERGREEN FOREST

RICE FIELD

MOIST MOUNTAIN FOREST

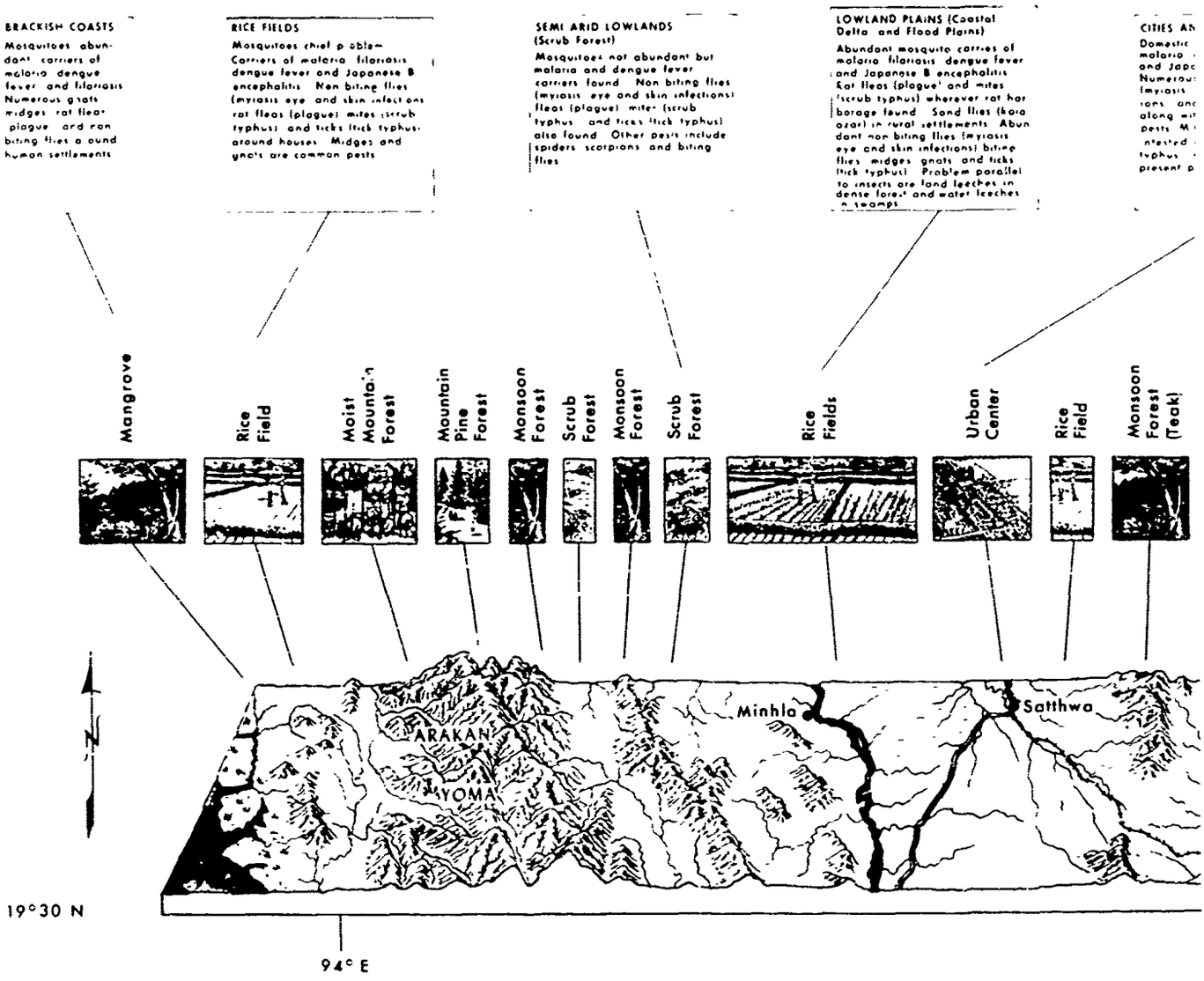
RURAL VILLAGE

MOUNTAIN PINE FOREST

URBAN CENTER

PHYSIOGRAPHIC CROSS-SECTI

SHOWING VEGETATION



A

F

ECTION THROUGH CENTRAL BURMA

TION AND HARMFUL INSECTS

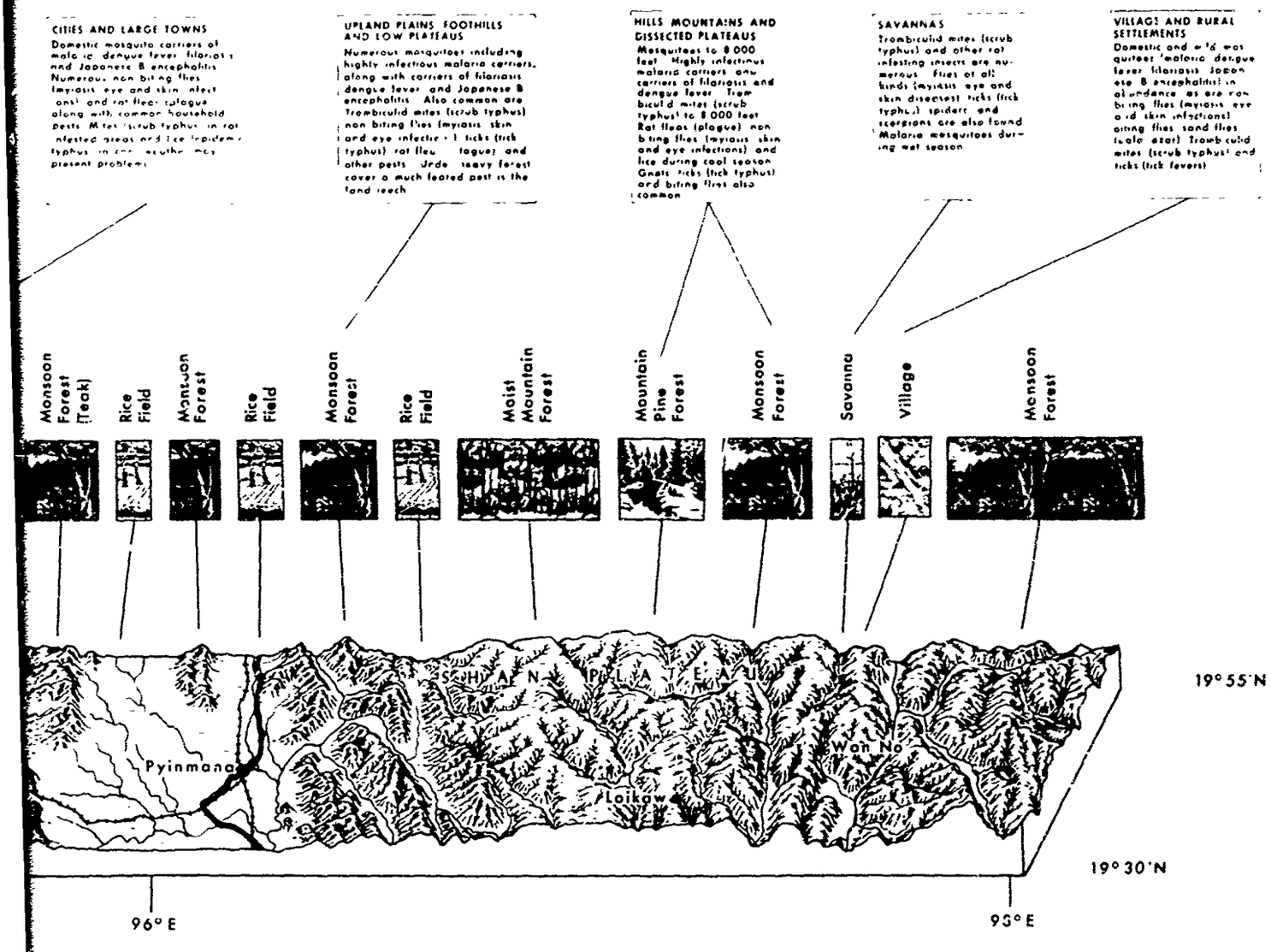


Figure - 7

B

PHYSIOGRAPHIC CROSS-SECTION E)

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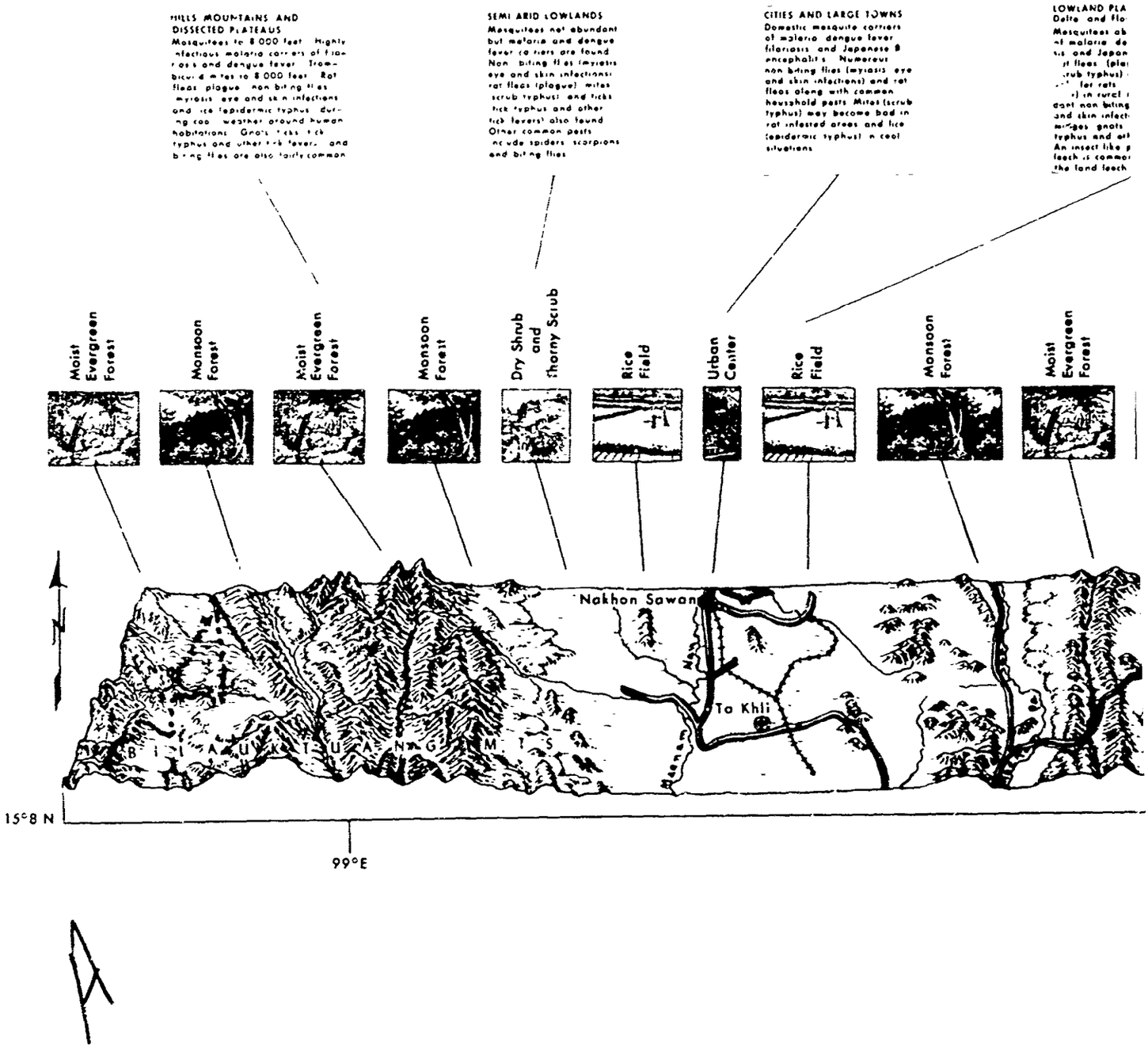


CTION EXTENDING EAST AND WEST THROUGH CENTRAL THAILA

WING VEGETATION AND HARMFUL INSECTS

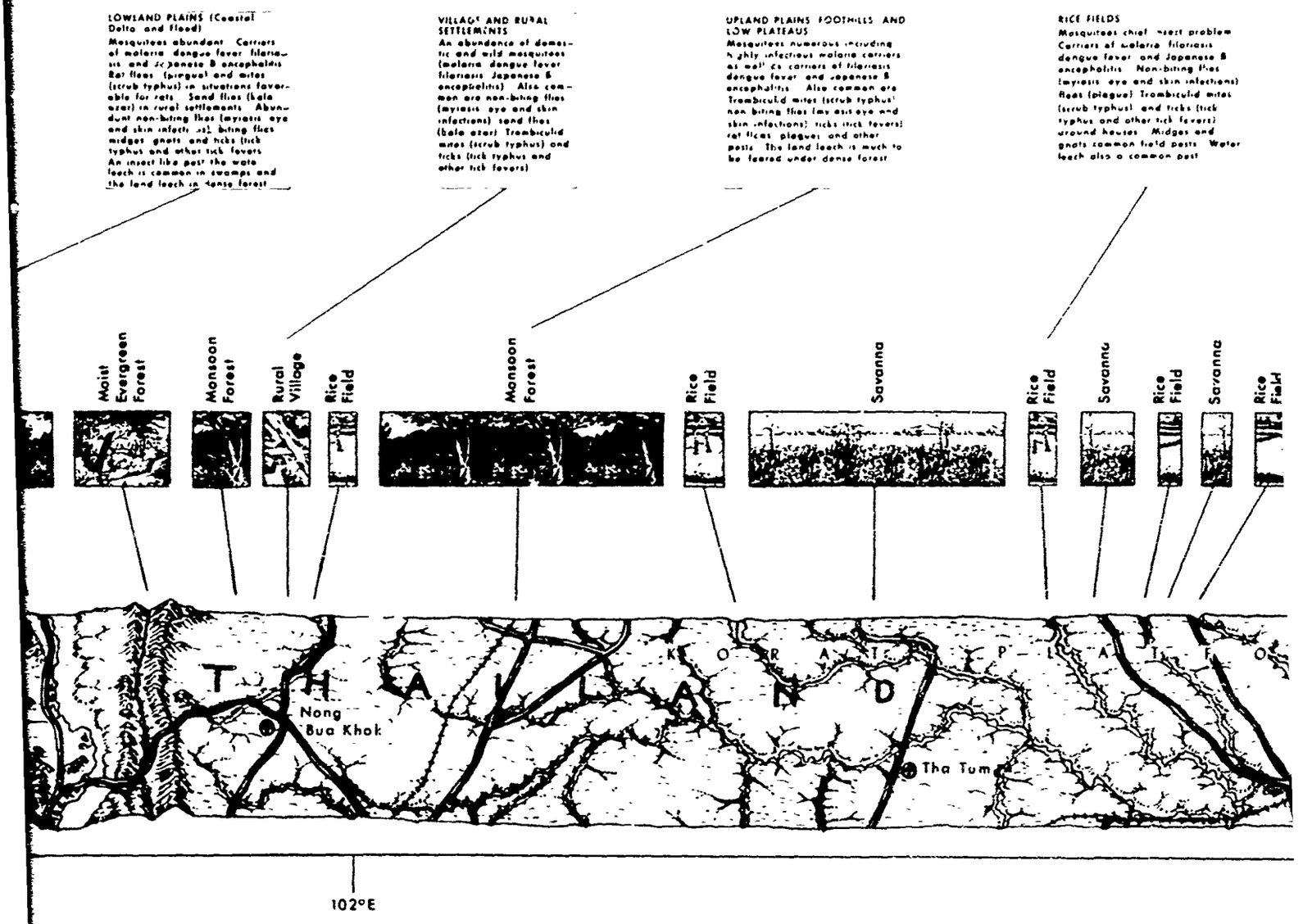


Figure 8a

B

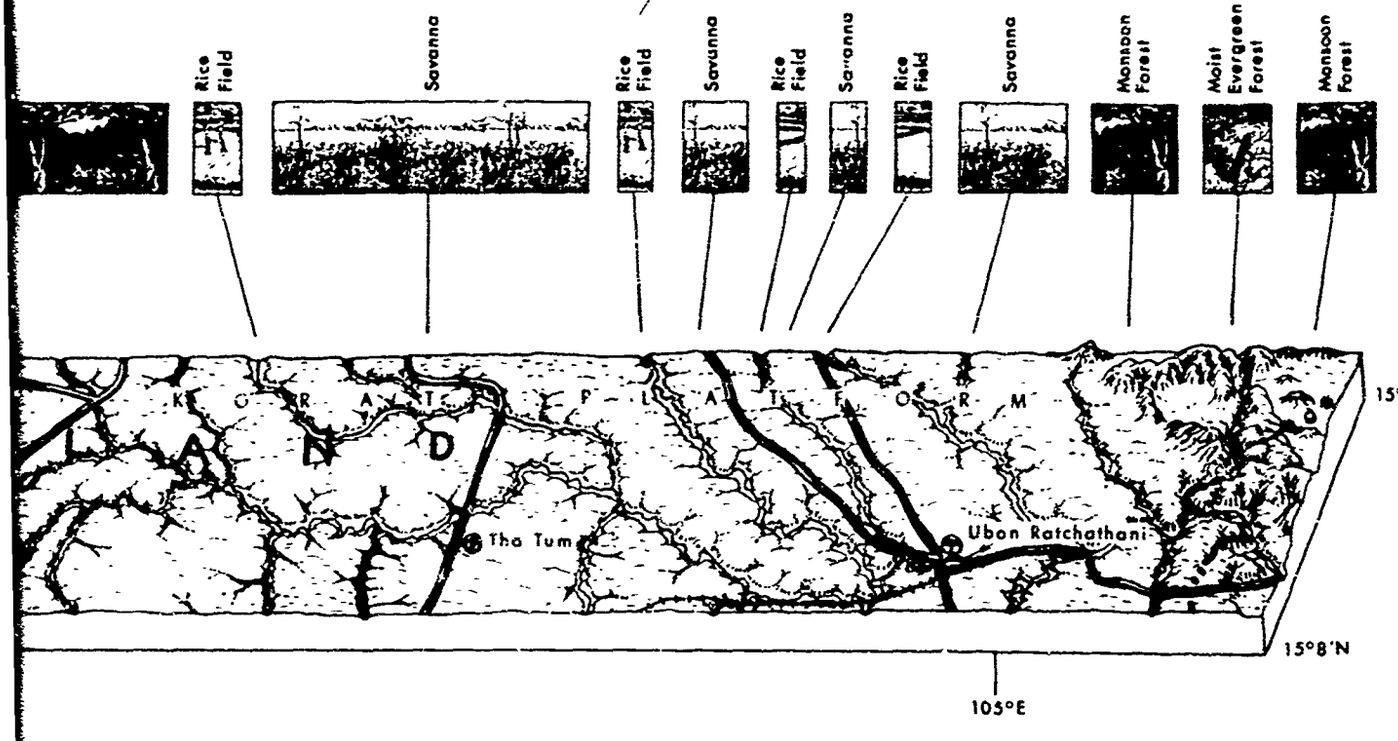
ND WEST THROUGH CENTRAL THAILAND

RMFUL INSECTS

UPLAND PLAINS FOOTHILLS AND LOW PLATEAUS
Mosquitoes numerous including highly infectious malaria carriers as well as carriers of filariasis dengue fever and Japanese B encephalitis Also common are Trombiculid mites (scrub typhus) non biting flies (myiasis eye and skin infections) ticks (tick fevers) rat fleas (plague) and other pests The land leech is much to be feared under dense forest

RICE FIELDS
Mosquitoes chief insect problem Carriers of malaria filariasis Dengue fever and Japanese B encephalitis Non-biting flies (myiasis eye and skin infections) Rats (plague) Trombiculid mites (scrub typhus) and ticks (tick typhus and other tick fevers) around houses Midges and gnats common field pests Water leech also a common pest

SAVANNAS
Trombiculid mites (scrub typhus) and other rat infesting insects are numerous Non-biting and biting flies (myiasis eye and skin infections) ticks (tick typhus and other tick fevers) spiders and scorpions are also found Mosquitoes are not a serious pest except during the rainy season



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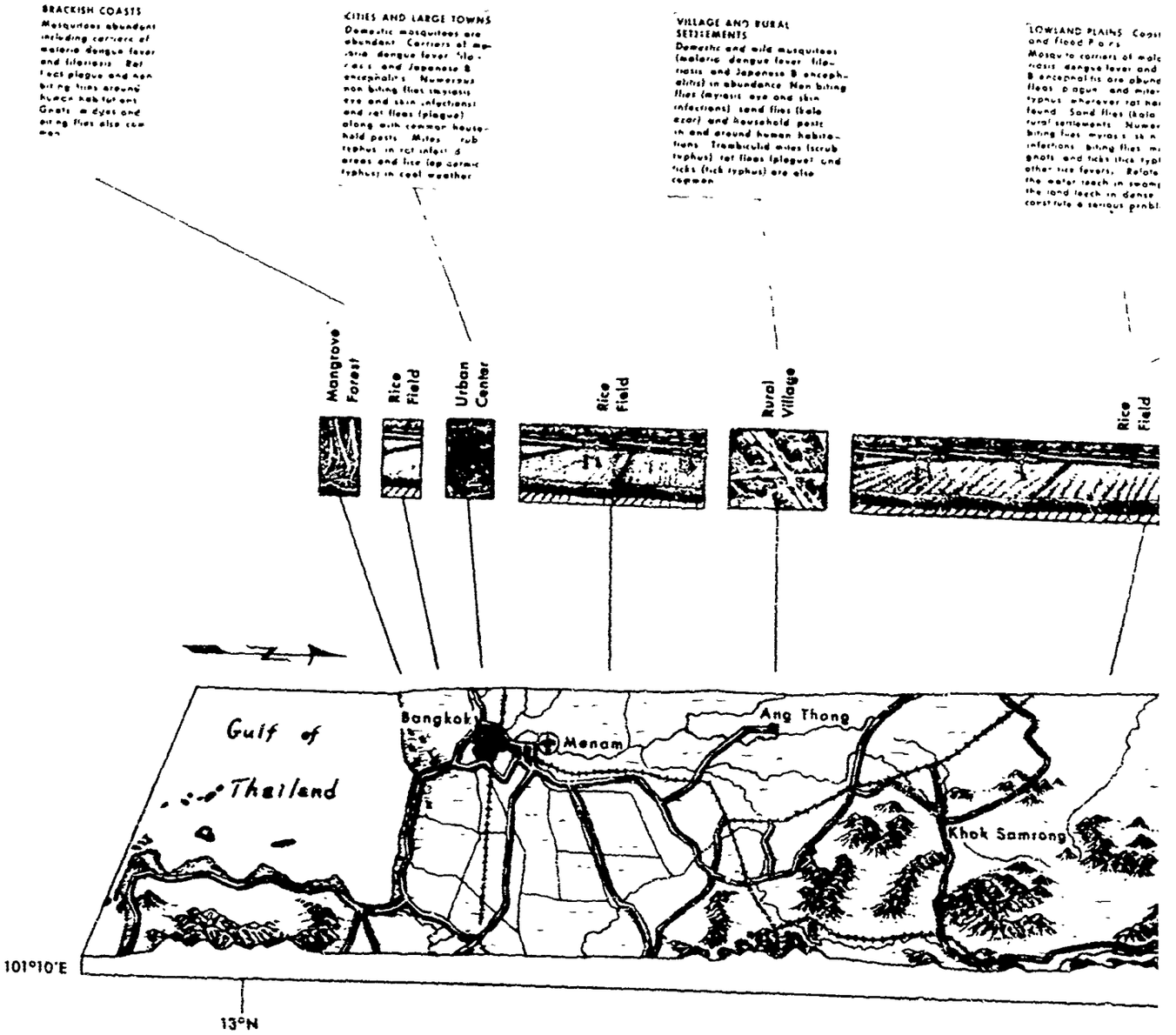


A

-SECTION EXTENDING NORTH AND SOUTH THROUGH CENTRAL T

SHOWING VEGETATION AND HARMFUL INSECTS

LOWLAND PLAINS Coastal Delta and Flood Plain
Mosquito carriers of malaria, filariasis, dengue fever, and Japanese B encephalitis are abundant. Rat fleas (plague) and mites (scrub typhus) wherever rat harborage found. Sand flies common in rural settlements. Numerous non-biting flies (myiasis, skin and eye infections), biting flies, midges, gnats and ticks (tick typhus and other tick fevers). Feared pests, the water leech in swamps and the land leech in dense forest, constitute a serious problem.

RICE FIELDS
Mosquitoes especially numerous, including carriers of malaria, dengue fever, filariasis and Japanese B encephalitis. Non-biting flies (myiasis, eye and skin infections), rat fleas (plague), mites (scrub typhus) and ticks (tick typhus and other tick fevers) around houses. Midges and gnats are common pests. More feared than insects is the water leech, common in all areas.

UPLAND PLAINS, FOOTHILLS AND LOW PLATEAUS
Numerous highly infectious malaria mosquitoes along with carriers of filariasis, dengue fever, and Japanese B encephalitis. Also common are rat-borne Trombicula mites (scrub typhus) and fleas (plague). Ticks (tick typhus and other tick fevers) are fairly numerous and non-biting flies (myiasis) are serious pests wherever man or domestic animal found. A much feared pest under heavy forest cover is the land leech.

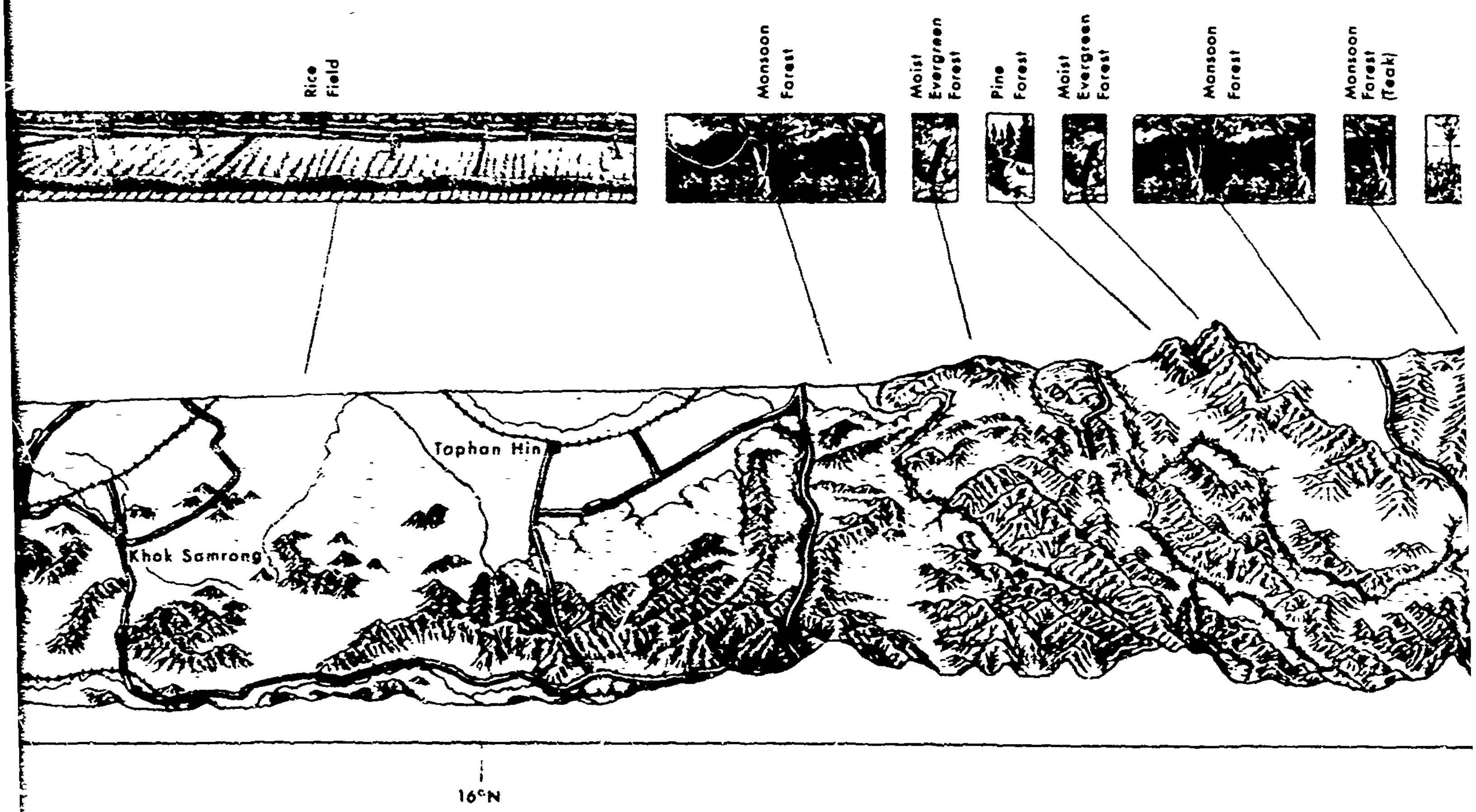


Figure 8b

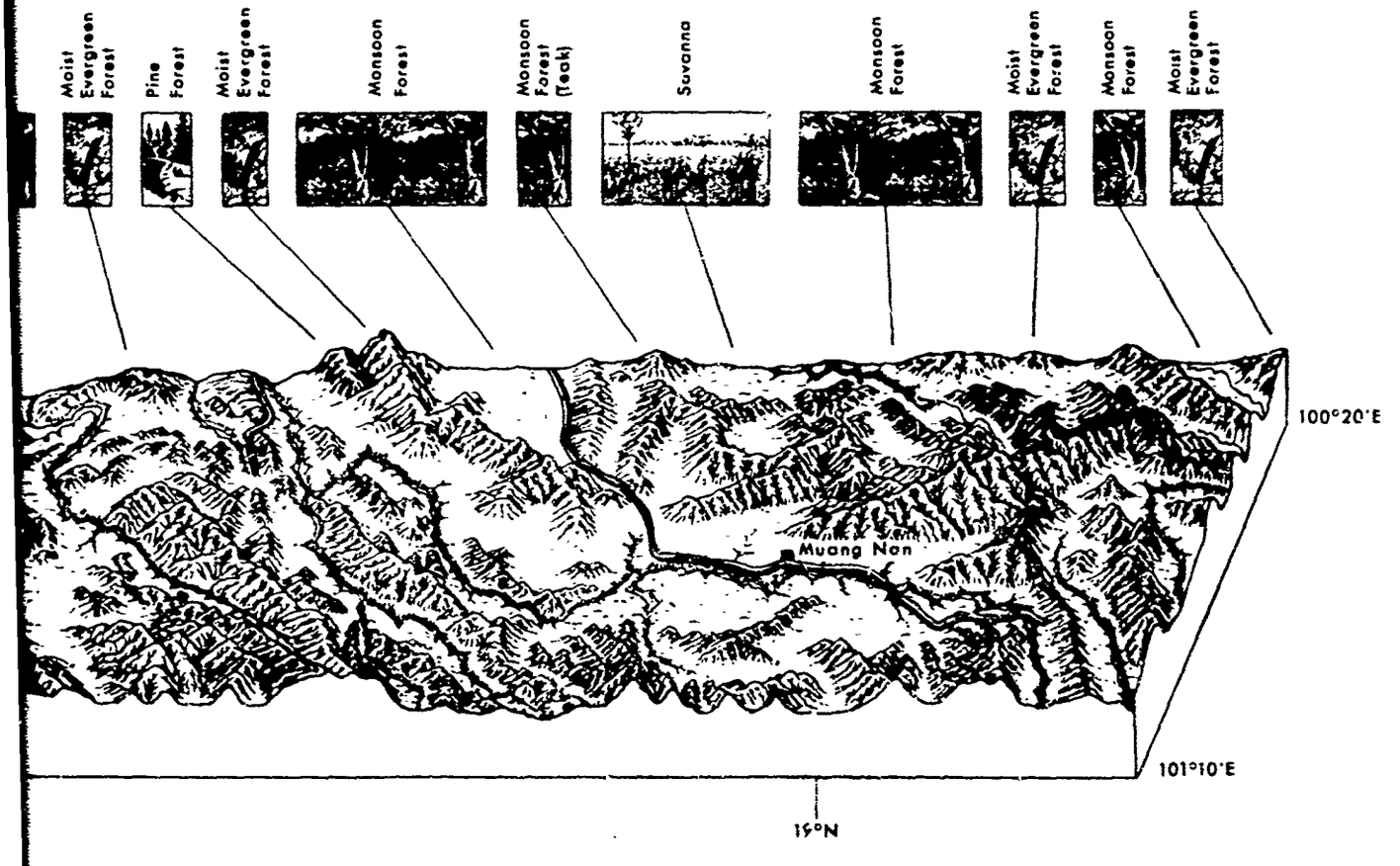
UTH THROUGH CENTRAL THAILAND

L INSECTS

UPLAND PLAINS FOOTHILLS AND LOW PLATEAUS
Numerous highly infectious malaria mosquitoes along with carriers of filariasis dengue fever and Japanese B encephalitis. Also common are rat borne Trombiculid mites scrub typhus and fleas (plague). Ticks (tick typhus and other tick fevers) are fairly numerous and non biting flies (myiasis) are serious pests wherever man or domestic animals found. A much feared pest under heavy forest cover is the land leech.

HILLS MOUNTAINS AND DISSECTED PLATEAUS
Mosquitoes to 8,000 feet. Highly infectious carriers of malaria as well as carriers of filariasis and dengue fever. Trombiculid mites scrub typhus to 8,000 feet. Rat fleas (plague) non biting flies (myiasis) eye and skin infections biting flies gnats and ticks (tick fevers) are common. There are ice during the cooler season.

SAVANNAS
Trombiculid mites scrub typhus and other rat infesting insects are numerous. Non biting flies myiasis eye and skin infections biting flies ticks (tick typhus and other tick fevers) spiders and scorpions are common. Malaria mosquitoes during wet season.



c

PHYSIOGRAPHIC CROSS-SECTIO

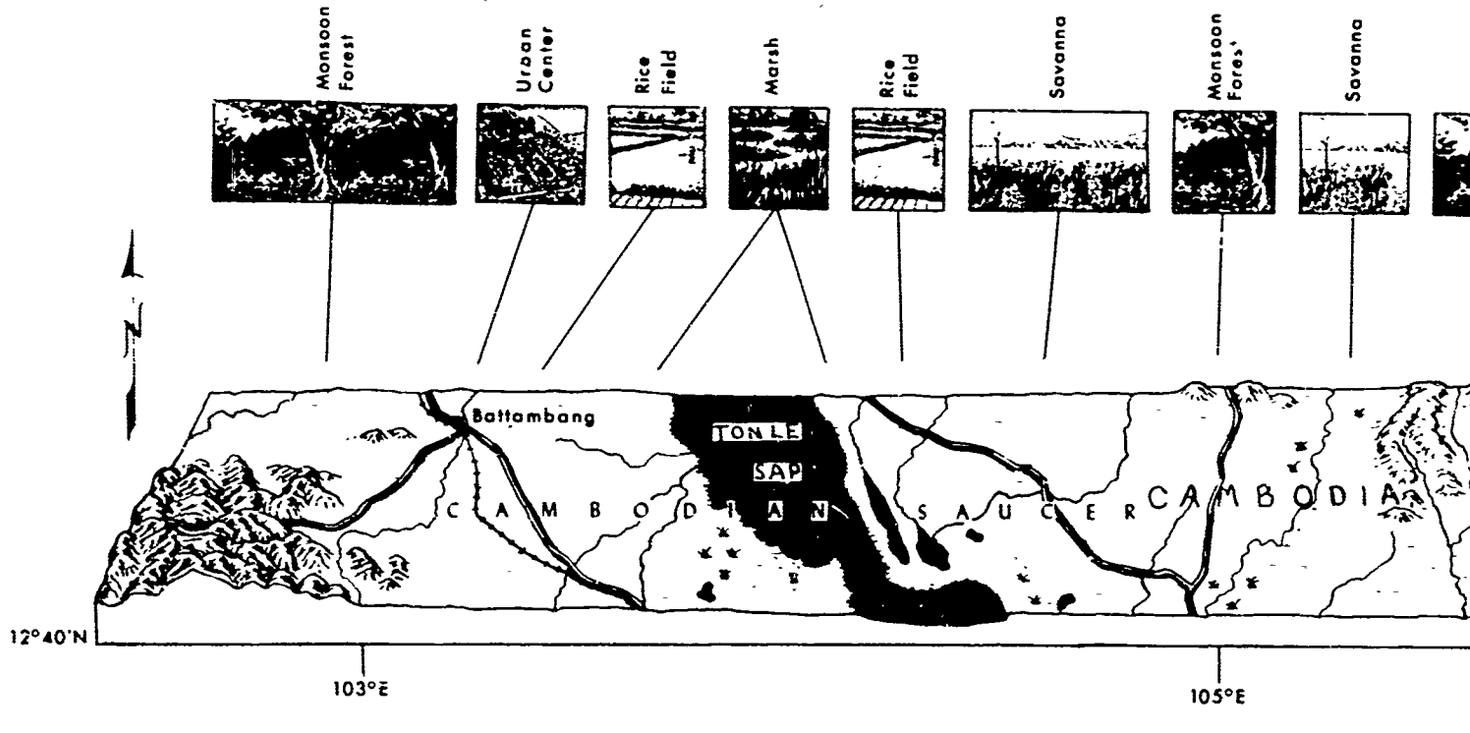
SHOWING VEGE

CITIES AND LARGE TOWNS
Domestic mosquito carriers of malaria dengue fever filariasis and Japanese B encephalitis Numerous non biting flies (myiasis eye and skin infections) and rat fleas (plague) along with common household pests Mites (scrub typhus) in rat infested areas and lice in cooler periods may present problems

RICE FIELDS
Mosquitoes numerous carriers of malaria dengue fever Japanese B encephalitis and filariasis Non biting flies (myiasis eye and skin infections) rat fleas (plague) ticks (tick typhus and other tick fevers) and sand flies (kala azar) around houses Vesicating beetles may be a problem on occasion A related pest the water leech is much feared Midges and gnats are common

MARSHES
Mosquito carriers of malaria filariasis dengue fever and Japanese B encephalitis are common as are non biting flies (myiasis eye and skin infections) Trombiculid mites (scrub typhus) and rat fleas (plague) Gnats ticks (tick typhus and other tick fevers) spiders and biting flies also found

SAVANNAS
Trombiculid mites (scrub typhus) fleas (plague) and other rat infesting insects are numerous Non biting flies (myiasis eye and skin infections) and ticks (tick typhus other tick fevers) along with spiders scorpions Mosquitoes carriers of malaria dengue fever and filariasis abundant during wet season



A

OSS–SECTION THROUGH CAMBODIA AND SOUTH VIETNAM

WING VEGETATION AND HARMFUL INSECTS

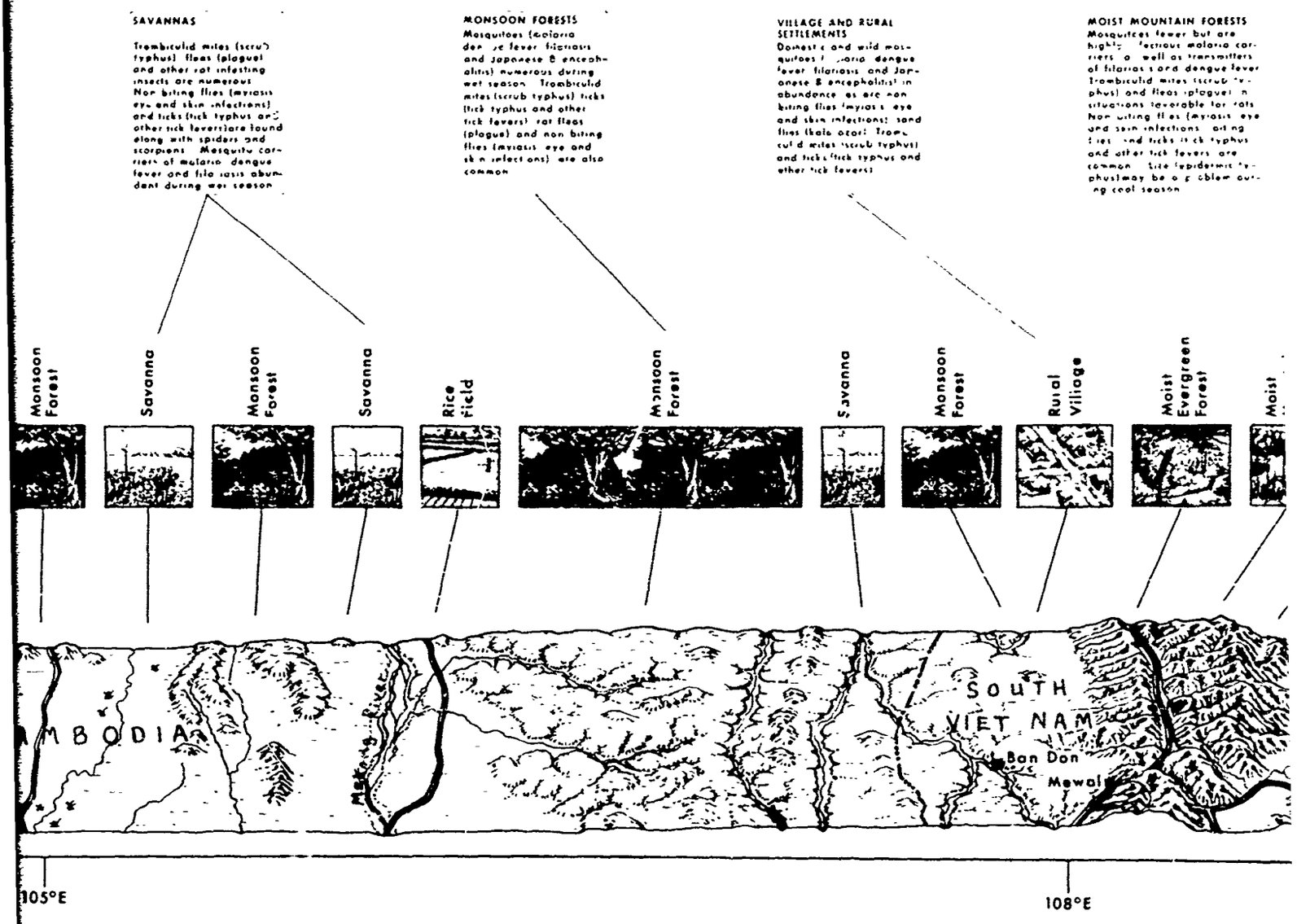


Figure 9

B

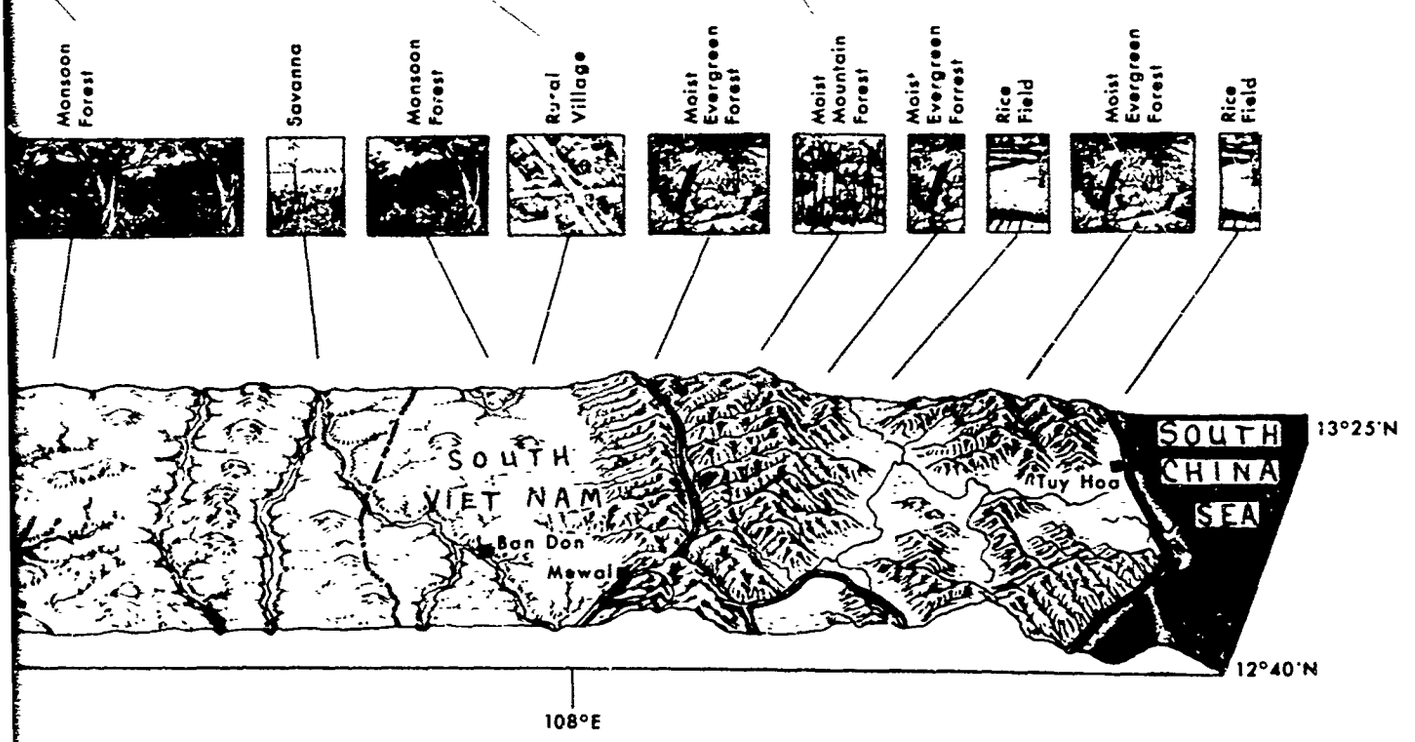
ODIA AND SOUTH VIETNAM

FUL INSECTS

VILLAGE AND RURAL SETTLEMENTS
Domestic and wild mosquitoes (malaria dengue fever filariasis and Japanese B encephalitis) in abundance as are non biting flies (myiasis eye and skin infections) sand flies (kala azar) Trombiculid mites (scrub typhus) and ticks (tick typhus and other tick fevers)

MOIST MOUNTAIN FORESTS
Mosquitoes fewer but are highly infectious malaria carriers as well as transmitters of filariasis and dengue fever. Trombiculid mites (scrub typhus) and fleas (plague) in situations favorable for rats Non biting flies (myiasis eye and skin infections) biting flies and ticks (tick typhus and other tick fevers) are common Lice (epidemic typhus) may be a problem during cool season

MOIST EVERGREEN FORESTS
Abundant mosquitoes (malaria filariasis dengue fever Japanese B encephalitis) non-biting flies (myiasis eye and skin infections) ticks (tick fevers) and mites (scrub typhus) are common as are biting flies gnats midges and a non insect the land leech more feared than most insects Sand flies (kala azar) near houses and barns



C

PHYSIOGRAPHIC CROSS-SECTION THROUGH SOI

NORTHERN SOUTH VIETNAM SHOWING VEGETATION

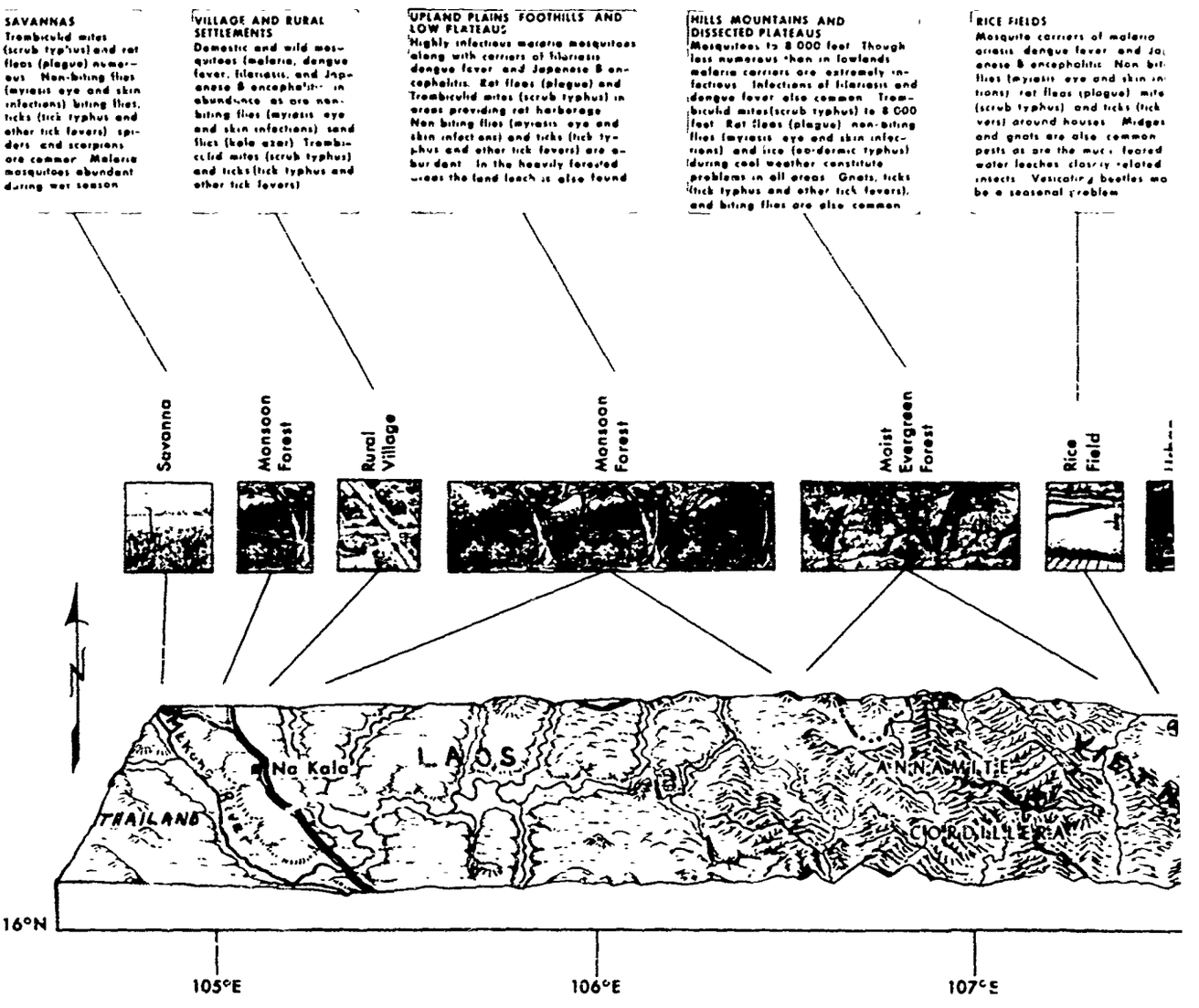


Figure 10

OSS-SECTION THROUGH SOUTHERN LAOS AND NAM SHOWING VEGETATION AND HARMFUL INSECTS

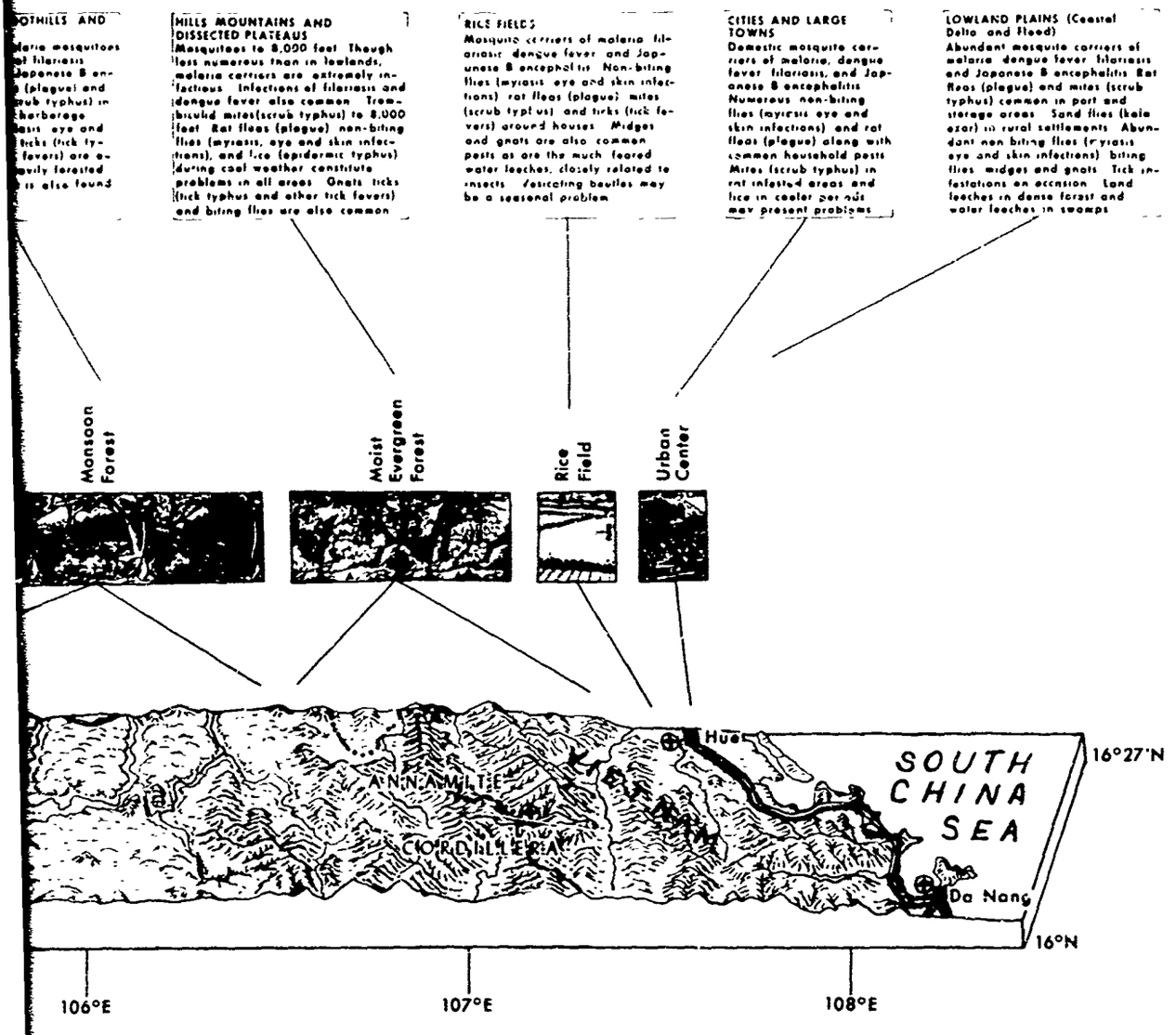


Figure 10

B

PHYSIOGRAPHIC CROSS-SECTION

SHOWING VEGI

UPLAND PLAINS, FOOTHILLS AND LOW PLATEAUS

Highly infectious mosquito carriers of malaria as well as carriers of dengue fever and filariasis. Trombiculid mites (scrub typhus) and fleas (plague) are common to all areas favorable to rats and mice. Non-biting flies (myiasis eye and skin infections), biting flies and ticks (tick typhus and other tick fevers) are also widespread. Lice (epidemic typhus) may become a problem in cool weather.

VILLAGES AND RURAL SETTLEMENTS

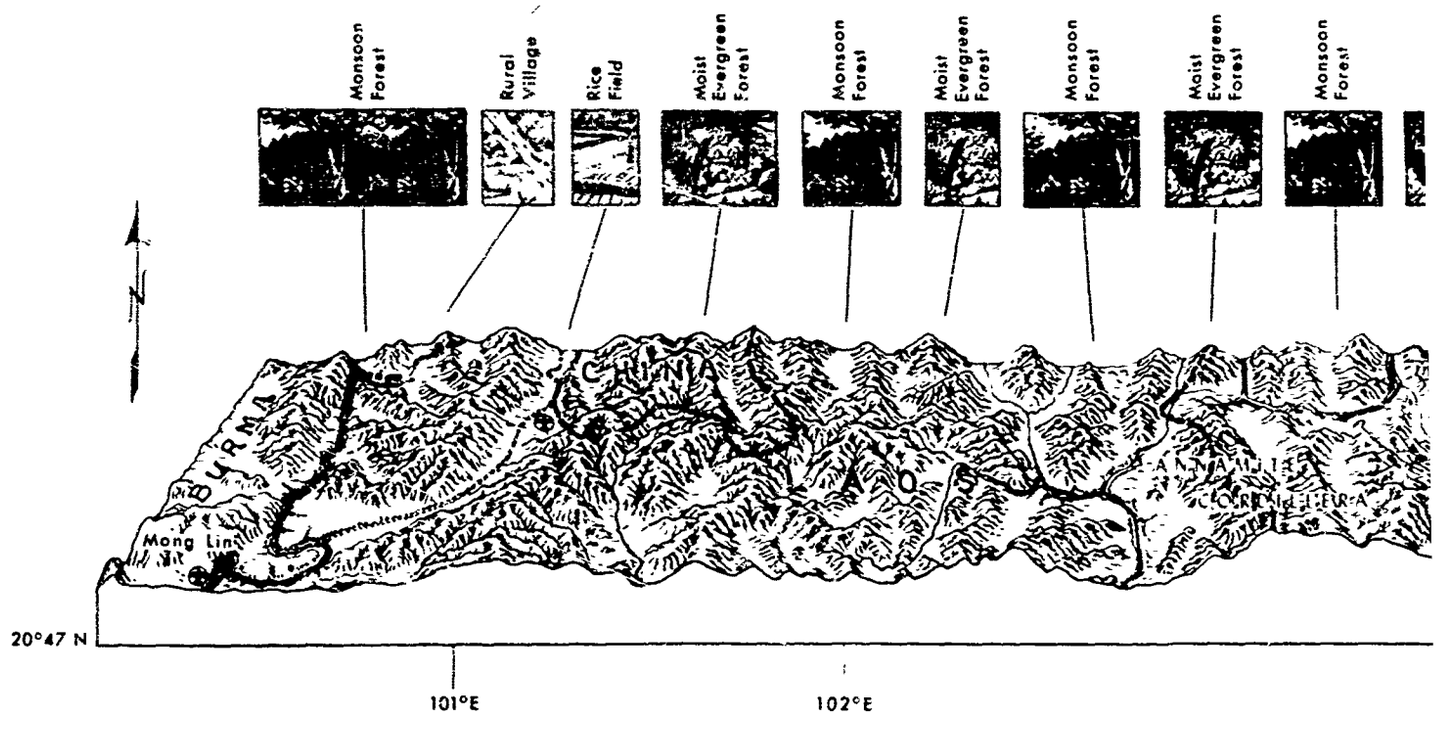
Domestic mosquitoes abundant. Carriers of malaria, dengue fever, filariasis and Japanese B encephalitis. Sand flies (kala azar), biting flies, and non-biting flies (myiasis eye and skin infections) are common to most human settlements as are rat fleas (plague) and mites (scrub typhus). Ticks (tick fevers) are also fairly numerous, and lice (epidemic typhus) may develop into a problem during cooler part of the year.

SAVANNAS

Mosquito carriers of malaria, dengue fever, and filariasis abundant during rainy season. Rat infesting species such as Trombiculid mites (scrub typhus) and fleas (plague) are also fairly numerous. Non biting flies (myiasis eye and skin infections), and biting flies found everywhere near man. Ticks (tick typhus) are also fairly abundant.

HILLS MOUNTAIN PLATEAUS

Highly infectious ... malaria. Also ... and filariasis. ... fairly free of mos... mites (scrub typhu... are found in or n... trons. Lice (epidem... cool weather prob... (myiasis eye and ... biting flies alway... serious during the...



ROSS–SECTION THROUGH NORTHERN LAOS AND NORTH VIETNAM
SHOWING VEGETATION AND HARMFUL INSECTS

HILLS MOUNTAINS AND DISSECTED PLATEAUS

Highly infectious mosquito carriers of malaria. Also carriers of dengue fever and filariasis. Higher summit areas are fairly free of mosquitoes. Rat borne mites (scrub typhus) and fleas (plague) are found in or near all human habitations. Lice (epidemic typhus) may be a cool weather problem. Non biting flies (myiasis, eye and skin infections) and biting flies always a problem are more serious during the summer season.

LOWLAND PLAINS

Abundant mosquitoes with carriers of malaria, dengue fever, filariasis and Japanese B encephalitis a common problem. Mites (scrub typhus) and fleas (plague) abundant in rat infested places. Non biting flies (myiasis, eye and skin infections) biting flies and sand flies (kala azar) around all human habitations. Ticks (tick typhus and other tick fevers) are common as are midges and gnats. Lice (epidemic typhus) may be found during cooler part of year. Vesicating beetles may constitute a problem in late summer.

RICEFIELDS

Mosquito control measures have reduced disease carriers here though infections of malaria, filariasis, dengue fever and Japanese B encephalitis do occur. Rat fleas (plague) and mites (scrub typhus) may be found along with ticks (tick typhus and other tick fevers), non biting flies (myiasis, eye and skin infections), sand flies (kala azar) and biting flies. Midges and gnats are common pests along with vesicating beetles in late summer.

CITIES AND LARGE TO

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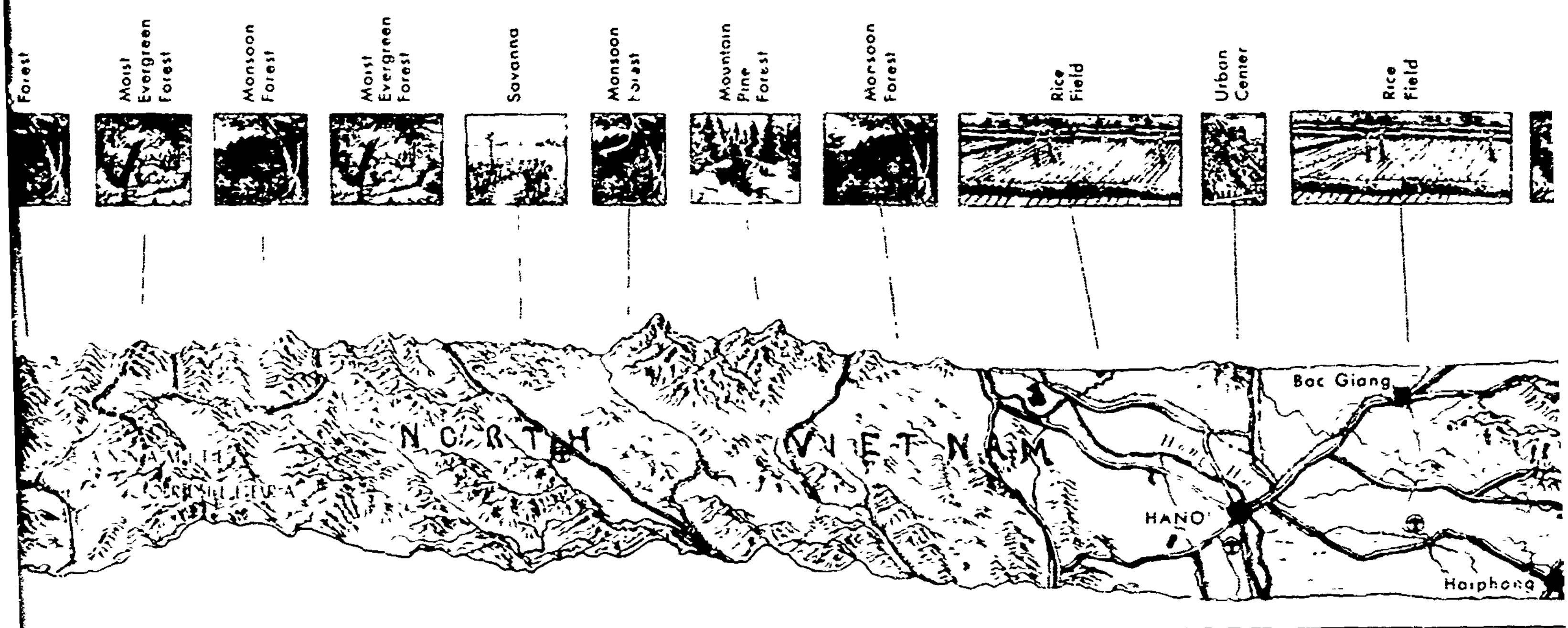

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Figure 11a

RN LAOS AND NORTH VIETNAM

FUL INSECTS

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RICEFIELDS

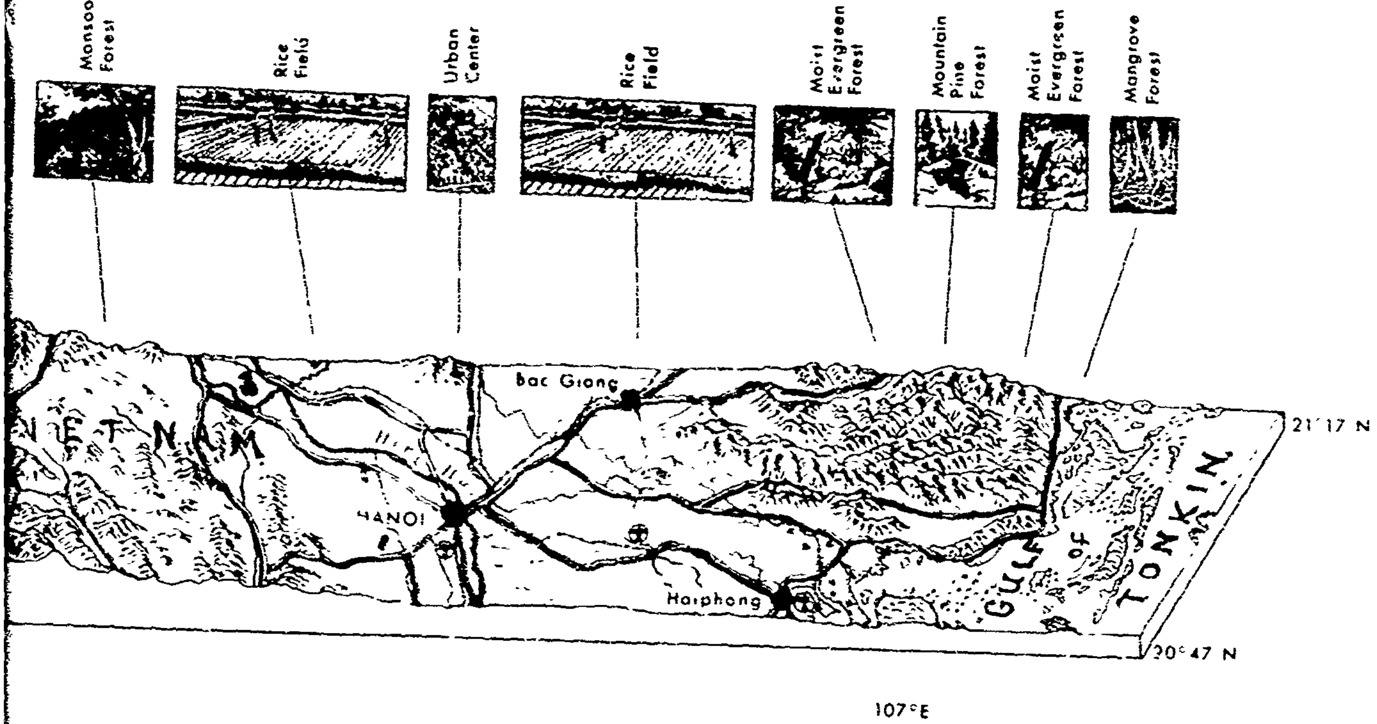
Mosquito control measures have reduced disease carriers here though infections of malaria, Aedes dengue fever and Japanese B encephalitis do occur. Rat fleas (plague) and mites (scrub typhus) may be found along with ticks (tick typhus and other tick fevers), non biting flies (myiasis, eye and skin infections), sand flies (bela azar) and biting flies. Midges and gnats are common pests along with vesicating beetles in late summer.

CITIES AND LARGE TOWNS

Mosquito carriers of disease under fairly good control. Possible carriers of malaria, dengue ever filariasis and Japanese B encephalitis are found. Under crowded conditions and in warehouse or storage areas rat borne fleas (plague) and mites (scrub typhus) are common. Non biting flies (myiasis, eye and skin infections) are abundant. Lice (epidemic typhus) may be a problem during cool weather particularly where crowded.

BRACKISH COASTAL MARGINS

Infectious mosquito carriers of malaria are present along with carriers of dengue fever, filariasis and Japanese B encephalitis. Mites (scrub typhus) and fleas (plague) found in rat-infested areas such as docks and warehouses. Ticks (tick typhus and other tick fevers) are found around human habitations. Midges and gnats are common pests.



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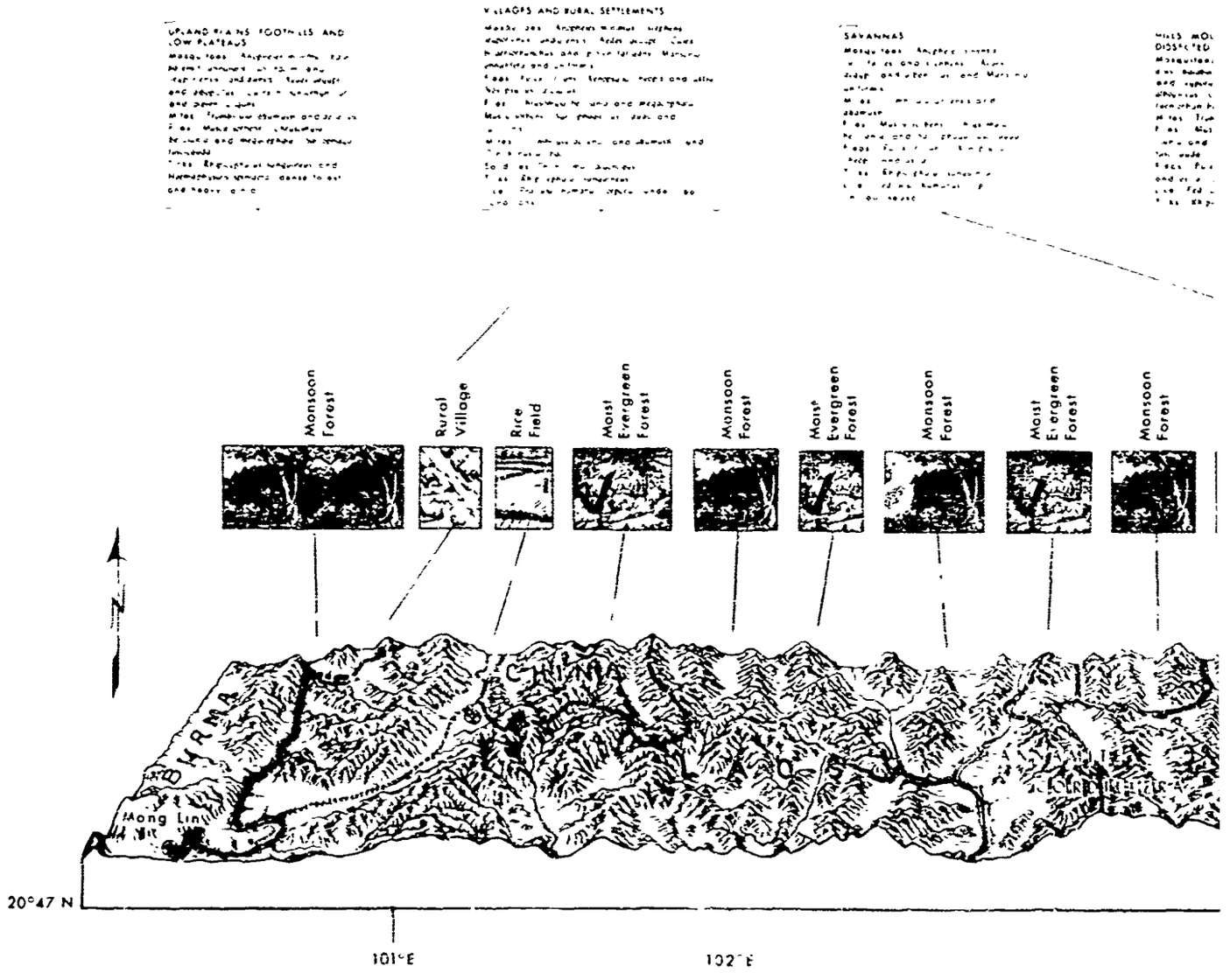
PHYSIOGRAPHIC CROSS-SECTION

SHOWING VEGETATIC



S-SECTION THROUGH NORTHERN LAOS AND NORTH VIETNAM

VEGETATION AND HARMFUL ARTHROPOD SPECIES

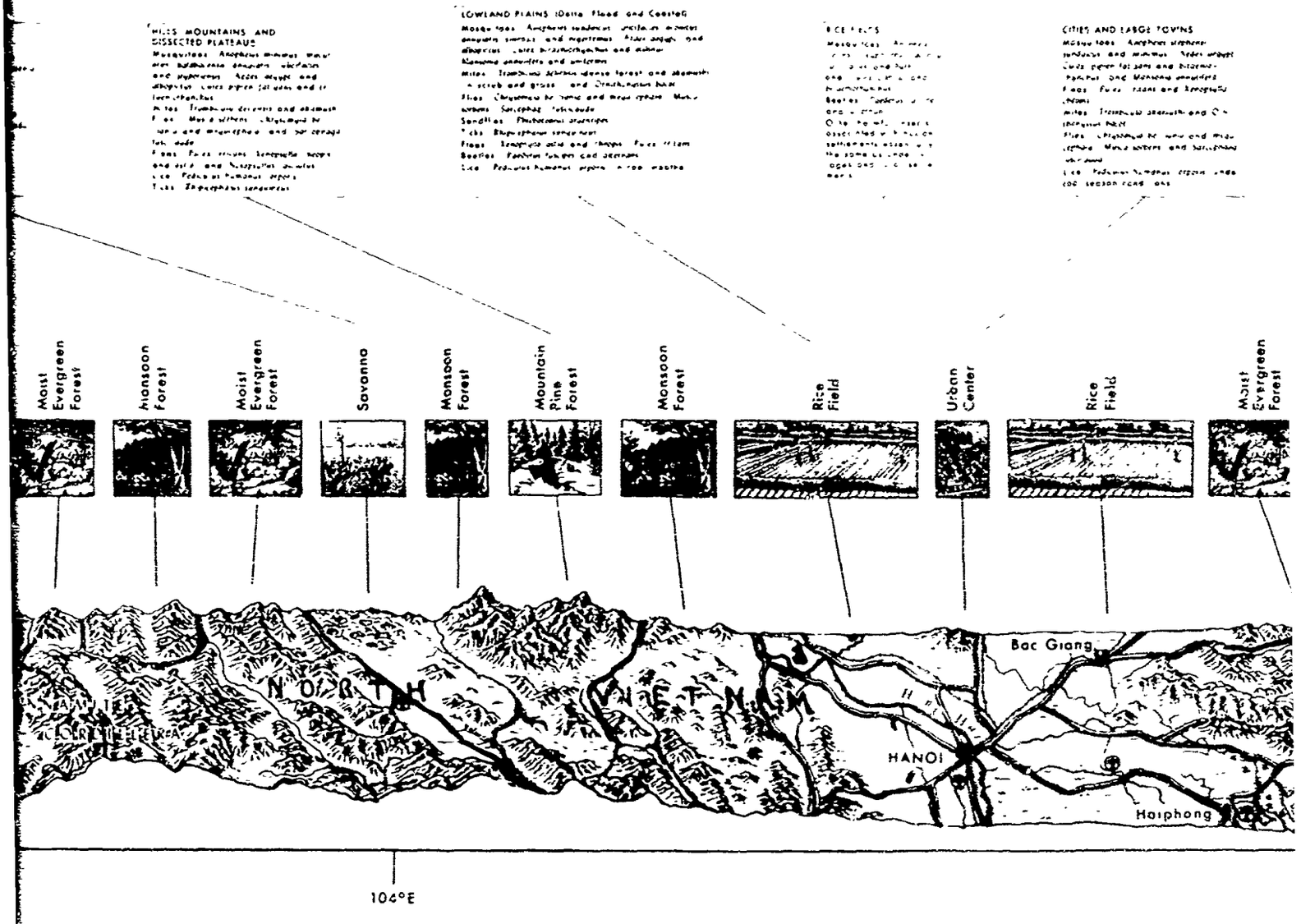
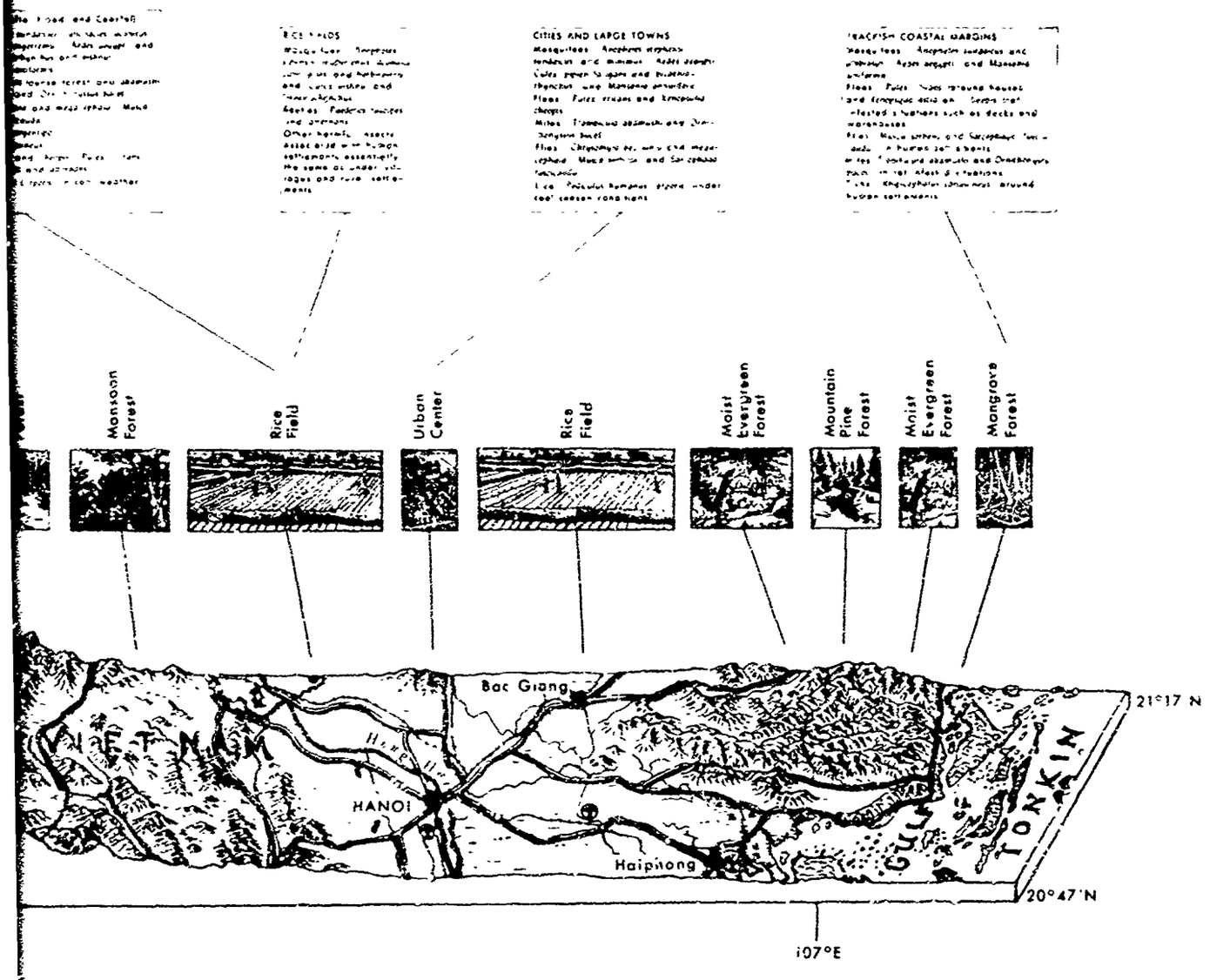


Figure 11b

B

ERN LAOS AND NORTH VIETNAM

ARTHROPOD SPECIES



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APPENDIX

TABLE I: HARMFUL INSECTS OF SOUTHEAST ASIA - ANOPHELINE MOSQUITOES

Species	Distribution	Breeding Situation	Elevations	Affinity to Man
A. aconitus Donitz	General	Most frequently breed in ricefields and fresh water ponds. Also, irrigation channels, tanks with grassy margins, creek pools, roadside drains, and river beds. Most often in ricefields just before harvest or when fallow.	More common in plains leading to hills, but found at both high and low elevations.	Adults found in both houses and cow sheds. Prefer cattle, but feed on man in the absence of cattle.
A. annularis Van der Wulp	General	Prefer still water with algal growth and floating vegetation. Found in slow moving water, but not preferred. Larvae found in tanks, swamps, ricefields, and borrow pits. On occasion in tree holes and cut bamboo.	Most common on plains, but may be found up to 7,000 feet.	Greatest frequency in cattle sheds, but also fairly common in houses. Considered basically zoophilic, but will attack man.
A. balabacensis Baisas (variant of A. leucosphyrus)	General	Species of forest and forest fringe commonly found in clear water of deeply shaded jungle pools, but also found to breed in open sunlight in bomb craters, wheel ruts and small ponds. Occasionally found in rock holes of mountain streams.	Broad elevational range. From near sea level to more than 3,600 feet.	Though generally classed as wild mosquito, will enter houses to feed. Most numerous in areas where men and cattle are.
A. barbirostris Van der Wulp	General	Prefer shaded water with emergent vegetation. Common in marshy forest areas. May be found in fresh and stagnant water, and rarely in brackish water. Common settings include grassy forest pools, springs and dam pools, irrigation ditches, with vegetation in ricefields, swamps, borrow pits, and artificial containers.	Broad elevation range, found in both plains and mountain streams.	Classed as wild mosquito but will bite anywhere at night and in shaded situations during the day. Prefers animal blood to that of man. Though generally more in houses, in Malaya no preference shown between houses and barns.
A. culicifacies Giles	General	Prefer clean, fresh water. Found in sluggish streams, irrigation channels, ricefields (while plants small or fields in fallow), ornamental water, swimming pools, and shallow wells. Occasionally in brackish water.	Generally in plains, but may be found up to 7,500 feet.	Most common in rural setting. Indifferent as to cattle or man in blood feeding. Greatest human affinity where cattle scarce. Rests in cowsheds and houses. Bites man freely.
A. fluviatilis James	Northern section from Indian to S. China border.	Prefers clean water with emergent vegetation in open sunlight, such as foothill streams, springs, irrigation ditches, lakes, and edges of swamps. Less common in ricefields. Moving water preferred.	Seldom below 1000 feet or above 5,000.	Breeds most commonly in immediate vicinity of human dwellings. Seems to prefer human blood to that of cattle.
A. jeyporiensis James	Noted in Burma and Indochina	Prefer moving waters of sluggish streams or slow flow of rice irrigation. Along marshy edges of lakes and ponds.	From lowlands to elevations of 6,000 feet.	Most frequently found in cattle sheds, but may also enter human dwellings.

Diurnal Feeding Pattern	Rest Pattern	Seasonal Distribution	Flight Range	Importance as a Disease Carrier
Begin to feed in early evening. Maximum about midnight.	Rest outdoors, especially along damp stream banks.	Found in abundance after rains. No pronounced seasonality in Southeast Asia, but heaviest in November and lowest in May and June.	Capable of good flight, 1,000 yards or more.	Malaria carrier of secondary importance in Indochina. Likely a carrier in other areas. Possibly involved in transmission of filariasis (Wuchereria bancrofti).
Begin to feed in early evening. Largely completed by 11 p.m.	Rest along overhanging stream banks and in cattle sheds. Attracted to artificial light and often rest near light source.	Found throughout year. Greatest tendency to enter houses during autumn. Peak in numbers in May, low during cooler months.	Capable of long flight. Up to 1,000 yds.	Malarier carrier of secondary importance. Possible carrier of filariasis (Wuchereria bancrofti).
Nocturnal activity with heaviest feeding late at night. Will feed outdoors as well as in houses.	Commonly along steep stream banks by day. Those which have fed in houses at night may rest in houses during day.	Numbers fluctuate during year. Peak Sept. to Nov.	Flight range up to 800 yards.	Malaria carrier of major importance in all S.E. Asia. Generally most important carrier in areas treated with DDT.
Principally at night but may feed in shade during day.	Rest by day in cool dark places, such as shaded stream banks and stone walls.	Continuous throughout year with favorable breeding sites. Large numbers in ricefields during early part of season, and also numerous as paddy water stagnates.	Relatively short flight range. Rarely more than 600 yards.	A malaria carrier but noted as important in Southeast Asia only when occurring in extremely large numbers. Possible carrier of filariasis (Wuchereria bancrofti and W. malayi).
Feed largely between 9 p.m. and 2 a.m.	Rests in cow sheds and houses in dark corners.	Greatest incidence during wet monsoon, but continuous throughout year. Lowest numbers in time of highest temperatures in late spring.	Long flight range, one-half to one mile.	Considered a carrier of malaria of moderate importance in Thailand and Burma.
Most take blood meal within 1 1/2 hours after dusk. Enter houses in first quarter of night.	Most rest outside along steep, shaded banks during day.	No pronounced seasonality noted.	Flight range up to 800 yards.	Considered a malaria carrier of limited importance in this area. Responsible for occasional intense malaria in areas where found.
Nocturnal feeder.	Rest by day in cattle sheds, or on shaded clay banks of streams.	Abundant in Arakan (Burma) in early part of year. Most common in hill sections from May through September.	Flight range up to 1,000 yards.	Considered a malaria carrier of minor importance in this area. Possible infector of Wuchereria bancrofti.

TABLE I: HARMFUL INSECTS OF SOUTHEAST ASIA - ANOPHELINE MOSQUITOES (Cont'd)

Species	Distribution	Breeding Situation	Elevations	Affinity to Man
A. jeyporiensis candidiensis Koidzumi	Noted in Burma, Indochina, and Thailand.	Prefers slow moving water. Found along grassy margins of streams and rivers in irrigation ditches, swamps, rice-fields, and seepage outlets. Especially abundant in foothill rivers.	Foothill rivers up to moderate upland elevations.	Anthropophilic, but will feed readily on cattle and other animals. Often found in human habitations.
A. kochi Donitz	General	Breed in small muddy pools, buffalo wallows, wheel tracks, sewage drains, rice fields, artificial containers, and swamps.	Primarily lowland species.	Usually found in houses at night, but more frequently in cattle sheds. Seem to prefer cattle to man.
A. letifer Sandosham	Peninsular Thailand and Malaysia	Preference for dark brown water of peat-filled ponds. Cool water preferred. Found in shaded pools. Will not breed in stagnant agricultural drains and brackish coastal waters when fresh water situations not available.	Lowland species.	May attack man in shaded areas during the day; and will enter houses for blood meal at night.
A. maculatus Theobald	General	Prefers water open to sky. A sun-loving species. Abundant in water with mats of grass roots and green algae. Found in streams and river beds with preference for seepage rivers. Found in cleared hilly areas and not in hill jungle. Noted in fast flowing streams in Burma.	Generally an upland species. Found at elevations from 3,000 to 8,000 feet.	Common in houses at night but not in daytime. Feeds with equal vigor on man or cattle. Human affinity in part dependent upon the number of cattle present.
A. minimus Theobald	General	Two distinct breeding situations varying with seasons. During dry season in edges of permanent waters such as rivers, streams, and spring-fed wells. During wet season found in slow-moving but protected water of irrigation ditches and drains of all sorts. Prefer clean, unpolluted water, generally slow-moving with grassy edges. Seldom in rice fields.	Chiefly in foothills, hills, and mountains. Breeds at elevations up to 5,000 feet. In Tonkin, incidence of malaria associated with minimus noted to increase from undulating plains upward to low mountains.	Strong preference for human blood. Chiefly found in houses. Rest outside by day only when woods reach close to houses. Even heavy rains will not prevent minimus from seeking hosts.
A. nigerrimus Giles	General	Shade loving species. Prefer bodies of water covered with vegetation. Swamps, fish ponds, borrow pits, heavily vegetated tanks, edges of slow moving streams, and rice fields are common sites. Occasionally in brackish water.	Generally a lowland species.	Prefer cattle to man. Rarely found in houses. Will bite man outdoors in evening, and in shade during day. Considered a wild species. Man not a primary host.

Diurnal Feeding Pattern	Rest Pattern	Seasonal Distribution	Flight Range	Importance as a Disease Carrier
Nocturnal feeder, usually starting about two hours after sundown.	Rest outside for most part. Seldom in human dwellings.	Most numerous during first half of year in Burma. Associated with premonsoon rains in Arakan.	Flight range up to one-half mile.	Important malaria carrier in Arakan, along Burma-Bengal border. Considered second in importance only to minimus in Indochina. Also carrier of Wuchereria bancrofti.
Largely nocturnal but may feed at any time.	Rest outside on shaded stone walls and banks. May rest in stables and houses.	Active all year over much of area. Greatest numbers in rainy season.	Not known.	Naturally infected with malaria.
Generally nocturnal feeder.	Rest outdoors during day, usually in dense shade.	Heaviest concentration during rainy months.	Flight range not known.	An important carrier of malaria in Malaysia. Also noted as carrier of filariasis (Wuchereria bancrofti and Wuchereria malayi).
Blood meals largely between 9 p.m. and 2 a.m.	Rest after 2 a.m. through daytime hours, largely along stream banks. Seldom rest in houses.	Continuous throughout the year. Maximum breeding times in Malaysia in March and September. Well adapted to dry season.	Flight range more than one-half mile.	A malaria carrier of major importance in Indochina only during epidemic periods. Considered a minor carrier in Burma. A vector of importance in hilly areas of Malaysia. Naturally and experimentally infected with Wuchereria bancrofti.
90% of blood feeding takes place after midnight. Very little activity during first 2-3 hours after sundown.	Rest in daytime in dark houses and huts--usually on dark floors or under beds or cots in lower half of room. May rest outside only when woods reach near houses.	Infections scattered throughout year. Highest figures in June, January, October, and December in Indochina. Periods between rains in Burma.	Usually a flight average less than one-half mile.	Considered the most dangerous malaria carrier in Southeast Asia, due partly to domestic habits and preference for human blood. Long-lived species. Possible infector of filariasis (Wuchereria bancrofti).
Anytime during evening, or in shade during day. Prefer cattle to human blood.	Rest by day, usually in well shaded situations.	Highest incidence in Malaya August to October.	Not completely known.	Natural infector of malaria in Indochina and Malaysia. Possible host for filariasis (Wuchereria bancrofti).

TABLE I: HARMFUL INSECTS OF SOUTHEAST ASIA - ANOPHELINE MOSQUITOES (Cont'd)

Species	Distribution	Breeding Situation	Elevations	Affinity to Man
A. sinensis Wiedemann	General	Clean water with emergent vegetation preferred. Basically a rice field mosquito. Found in rice fields, lakes, swamps, borrow pits, grassy pools, irrigation ditches, shallow wells, road drains, cisterns, and rarely in brackish water. Unshaded situations preferred.	Apparently a wide elevation range. Abundant in foothills.	More frequent in cattle sheds, but also in houses. Will bite man at night and in shade by day.
A. stephensi Liston	Noted in Burma, Indochina, and Malaya.	Prefers sunlit breeding sites. In urban situations breeds in artificial containers such as wells, cisterns, fountains, tanks, tubs, cellars, reservoirs, gutters, tin cans, hollows of machinery, etc. In rural areas in pools, streams, seepage banks, and slow-moving irrigation channels.	Apparently a broad elevational range.	Feeds freely on man (one of chief carriers in urban centers of India).
A. subpictus indefinitus (Ludlow)	Noted in Indochina	Prefers clean, unshaded fresh water pools, rivers, streams, flowing irrigation channels, lakes, and wells. Rarely but on occasion in brackish water. Ideal sites with duckweed and other aquatic herbs.	Generally lowland species. Coastal margins and river flood plains.	Frequent houses at night. Generally prefer animal blood but feeds readily on man.
A. sundaicus (Rodenwaldt)	Coastal and lowland areas of S.E. Asia	Prefers mildly saline water in presence of algae. Favorite sites behind embankments which protect ricefields from the sea, or where mangrove has been cleared. Also, where lagoons separated from sea by silting up of river mouths. May breed in waters polluted with sewage. Prefers sunlit sites.	Generally near tidewater margins. However, a fresh water form of species has been found as high as 3,200 feet.	Voracious feeders. Found in houses and cattle sheds. Generally ascribed as true house mosquito.
A. umbrosus (Theobald)	General	Prefers slow moving water in virgin jungle, usually in dense shade. Brown, peaty stagnant pools, water pockets along tree roots, springs, deep lakes, and strongly brackish water used for breeding sites. Sun-fearing species.	Generally low elevations. Coastal plains adjoining hills are common sites. Also reported in hill areas.	Most found in shaded forest or jungle, but may enter houses within this setting. Fierce biters. May bite man in houses or in dense forest.

Diurnal Feeding Pattern	Rest Pattern	Seasonal Distribution	Flight Range	Importance as a Disease Carrier
Move to feeding sites all through the night. In houses most numerous from 10-12 p.m.	Rest inside houses and outside. Leave feeding sites near dawn.	Relatively most important at rice harvest time. Occur throughout the year.	Flight range up to 1,600 yards.	Minor malaria carrier in North Vietnam. Chief carrier in two Hanoi epidemics. A carrier of moderate importance in Burma. Possible developmental host for filariasis (Wuchereria bancrofti and Wuchereria malayi). Possible carrier of Japanese B encephalitis.
Nocturnal feeder, most active just before midnight.	Rest inside by day in small dark crevices, creases of clothing, etc.	Breeds throughout year. Most abundant when rainfall fairly heavy and relative humidity is high. Late winter and spring show lower infection rates.	Strong fliers - may travel up to 3 miles.	Not considered to be an important malaria carrier in Southeast Asia realm. Naturally infected with Wuchereria bancrofti.
Nocturnal feeder.	Rest in all types of shelters--cow sheds, houses, buses, trains, ships, etc.	No real predictability from year to year. Most frequent malarial infections in spring and autumn.	Strong fliers. Numerous flights noted of over one mile.	Carrier of secondary importance in Indochinese area. Possible carrier of filariasis (Wuchereria bancrofti).
Bites man by day as well as at night. Tending to feed on man even in the presence of cattle.	Rest by day in houses, usually in rooms in which they have fed.	No real predictability from year to year. Most frequent malarial infections in spring and autumn.	Strong fliers - often over one mile.	Chief malaria carrier in coastal situations in Southeast Asia. Generally considered second to A. minimus in all of Southeast Asia. Possible infector of filariasis (Wuchereria bancrofti).
Feed at night largely on animals. In houses it attacks boldly, even under lights. Maximum blood feeding between 10 p.m. and 2 a.m.	Rest in jungle vegetation near breeding sites.	Little seasonality of occurrence. August to December in Malaysia.	Flight range of about 1,000 yards.	Malaria carrier. Not highly infectious, but relative abundance and longevity add to danger. Especially important along NW coast of Malaya.

TABLE II: HARMFUL INSECTS OF SOUTHEAST ASIA - MOSQUITOES OTHER THAN ANOPHELINE

Species	Distribution	Breeding situation	Elevations	Affinity to man
Aedes aegypti (Linnaeus)	General	Called mosquito of seaports, closely associated with human settlements. Breeds in all artificial collections of water, such as rain barrels, tanks, cisterns, tin cans, urns, and coconut shells. Also in tree holes, plant leaves and axils. May breed in fresh, chlorinated or brackish water, though fresh water preferred. Often breeds inside houses.	Most common on coastal plain, but also found up to 10,000 feet.	Considered most domestic of mosquitoes. Usually found within 1500 feet of human habitation. Attacks under cover, ankles, back of neck, under blankets. Most common along communications lines.
Aedes albopictus (Skuse)	General	Commonly found to breed in artificial collections of water near man. Also found in tree holes, rock holes, cut bamboo, leaf axils, and coconut shells.	Broad range. From coastal lowlands up to 6,000 feet.	Strongly anthropophilic but prefer to bite outdoors. Will enter home freely for blood meal.
Culex bitaeniorhynchus (Giles)	General	Sites with clear water in presence of filamentous green algae preferred. Paddy fields, agricultural drains, ponds, small lakes and pools, and along margins of mountain streams.	Most widespread in foothills, often in association with Anopheles minimus. Broad elevation range.	Enters houses and readily feeds on man. Will bite in or out of dwellings.
Culex fatigans Wiedemann	General	Larvae usually found near human habitation, in drains, cesspools, latrines, shallow wells, ditches, and almost any other open water. Can survive a high degree of salinity.	Broad elevation range	Strongly attracted to man. Feed actively only at night. Enter houses. Extremely abundant in most areas.
Culex gelidus Theobald (Colless)	Indochina, Burma, Thailand, & Malaysia	Breeds in ground pools with weeds, marshy tracts, swamps, and other natural collections of water. Also reported in rice fields and obstructed drains.	Not noted.	Enters houses, vicious biter.
Culex tritaeniorhynchus (Giles)	Thailand, Burma, and Indochina.	Generally a marsh mosquito, abundantly found in marshes, swamps and poorly drained flood plains. Also in rice fields and ground pools.	Broad elevation range.	Readily enters houses during evening hours. Feeds indiscriminantly on man and larger mammals.
Mansonia annulifera (Theobald)	General	Commonly found in fresh water pools, ponds, marshes, and backwaters. Often in water fouled by coconut husks.	Elevational range not known.	Strongly anthropophilic. Found in houses at night.
Mansonia dives (Schiner)	Burma, Thailand, and Indochina	Fresh water ponds, pools, breakwater swamps and marshes, commonly is associated with emergent vegetation.	Elevational range not known.	Enters houses and feeds on man.
Mansonia longipalpis (Van der Wulp)	Burma, Thailand and Malaysia	Swamp breeder, larvae often attached to roots of swamp trees. Often found on banks near rice fields and in ponds.	Not known.	Females generally anthropophilic.

Diurnal Feeding Pattern	Rest Pattern	Seasonal Distribution	Flight Range	Importance as a Disease Carrier
Bites day and night. Females must secure blood meal immediately after mating. Most active morning and evening hours. Will not feed in complete darkness.	Rest inside houses on dark clothing, usually in sleeping quarters. May be active at any time.	Found in all stages of development throughout the year.	Short flights are characteristic. Rarely found far from place of origin.	Chief carrier of dengue fever in all areas. Principal carrier of yellow fever wherever disease occurs. Possibly a carrier of filariasis. Infector of chikungunya.
Bite outdoors and most frequently during twilight hours. Do not bite at night.	Rest most frequently in woodland. Rest more at night than in day.	Not specifically noted.	Short flight range, usually no more than 200 yards.	Possible carrier of Japanese B encephalitis, and carrier of dengue fever where disease present. Capable of transmitting yellow fever and possibly filariasis and chikungunya.
Generally nocturnal. Rarely during day.	Females rest in houses during day.	Seasonality of occurrence not known.	Flight range not known.	Carrier of filariasis (Wuchereria bancrofti).
Nocturnal feeder.	Rest in buildings during day.	Found all year over most of area. Highest incidence in Malaya in March and December.	Long flight range - 3 to 4 miles.	Carrier of Wucheria bancrofti.
Not known.	Not known.	Active throughout much of year; heaviest concentrations in wet season.	Not known.	Naturally infected with Wuchereria malayi and Wuchereria bancrofti. Suspected carrier of Japanese B encephalitis.
Feeds at any time during night. Infrequently during day.	Generally rest indoors by day.	Greatest frequency of disease at end of wet season.	Flight range not known.	Generally regarded as the principal carrier of Japanese B encephalitis. Reservoir hosts are likely birds.
Generally a nocturnal feeder.	Rest pattern not known.	Seasonality not known.	Flight range not known.	Probably the most important carrier of Wucheria malayi (filariasis) in Far East.
Feeding pattern not noted.	Rest pattern unknown.	Seasonality not known.	Flight range not known.	Carrier of Wuchereria malayi (filariasis).
May feed day or night.	Not known.	Not known.	Long flight range.	Most important carrier of Wuchereria malayi in Malaya.

TABLE II: HARMFUL INSECTS OF SOUTHEAST ASIA - MOSQUITOES OTHER THAN ANOPHELINE (Cont'd)

Species	Distribution	Breeding situation	Elevations	Affinity to man
Mansonia uniformis (Theobald)	Burma, Indochina, and Thailand.	Commonly found in pools. Open terrain preferred over forest. Found rarely in mangrove swamps.	Elevational range not known.	Generally anthropophilic. Found in houses and outside around stables where cattle and horses are kept.

Diurnal Feeding Pattern	Rest Pattern	Seasonal Distribution	Flight Range	Importance as a Disease Carrier
May bite day or night in houses or outside, but most often considered a nocturnal feeder - shortly after dusk.	Rest among low-growing plants by day.	Seasonality not known.	Long flight range.	Important carrier of Wuchereria malayi (filariasis).

TABLE III: HARMFUL INSECTS (OTHER THAN MOSQUITOES) IN SOUTHEAST ASIA

Species	General Distribution	Breeding Situation and/or Environmental Adaptation	Elevations Found
Aphiochaeta scalaris Heigen flesh fly	Malaysia	Lay eggs in cuts and sores.	Not known.
Chrysomyia bezziana Villeneuve non-biting fly	General	Deposits eggs only in infections of live tissue. Occurs in vicinity of cattle and other mammals. Feed on fresh cow dung, flowers, and honey dew. Eggs glued to dry skin over bruises or abscesses. Occasionally in places soiled by excrement or blood from wounds. After hatching larvae feed near skin surface for a time and then burrow deeply into living tissue.	Broad elevation range.
Chrysomyia megacephala (Fabricius) non-biting fly "Oriental blue bottle"	Indochina and Burma. Likely in other adjacent areas.	Commonly breeds in decomposing animal matter, particularly the dead bodies of animals. Rarely deposits eggs in diseased live animal tissue. May deposit eggs in other food stuff.	Apparently broad elevational range.
Musca sorbens Wiedemann Close relative of common house fly.	General	Eggs deposited in horse, cow, or human feces, especially in single deposits. Commonly found on cattle or horses far from human dwellings.	Broad range.
Phlebotomus argentipes Annandale and Brunetti sand fly	Noted in Indochina and likely found in other areas.	Appears capable of breeding wherever there is unprotected soil high in organic matter. Contaminated ground within 20 yards or so of dwellings, or cattle sheds. Favorite haunts of adults are badly lit cattle sheds and stables, or bathrooms of houses. Generally seek to avoid wind, sun, and full daylight.	Warm moist climate up to 4,000 feet.
Sarcophaga fuscicauda Bottcher or S. peregrina Robineau-Desvoidy "flesh fly"	Indochina and Burma. Likely in adjacent areas.	Breeds in wide variety of substances including meat and human excrement. Closely associated with man. Species oviparous, female giving birth to fairly large and active larvae.	Apparently broad range.
Sarcophaga ruficornis Fabricius non-biting fly	General	Oviparous, female giving birth to active larvae. Normally deposited on carrion, excrement, and on slightly tainted meat, and possibly on diseased body tissues.	Unknown - likely broad range.
Nosopsyllus fasciatus Bosc d'Antic flea	Indochina and Thailand.	Parasitic on vertebrate hosts, chiefly rats and mice. Found in situations attractive to rats and mice. Seem to be favored by relatively cool conditions.	At variable elevations.
Pulex irritans Linnaeus flea	General	Breeds freely in all situations occupied by man. Tolerant of wide range of environmental conditions. Man primary host, but found on dogs, squirrels, and other animals. Deposit eggs in clothing, on beds, and in cracks of floors.	Found essentially everywhere man found. Common in both plains and mountains.

Affinity to Man	Seasonality of Occurrence	Means of Transmission	Role as Disease Carrier
Not known.	Not known.	Infect by depositing larvae in open wounds and cuts.	Infector of myiasis.
Flies attracted to any discharge from infection. Inflamed eyes a common point of attack. Cattle chief host. Not commonly found in houses.	Little seasonality in warm moist areas. Areas with cool seasons will have reduction in infection during cool period.	Direct infection by deposition of eggs on human host. Eyes chief point of attack but found on almost every part of human body - sinuses, ears, nasal cavities, genital and rectal areas.	Chief infector of myiasis. Appears to be a major problem in all areas of reported incidence.
Common market place fly, especially on meats and sweets.	Seasonally pronounced only where there is a distinct cool season.	Direct infection by depositing larvae on human host. Affect eyes primarily, but also found in genital areas, nasal cavities, sinuses, ears, and rectal areas.	Infector of secondary importance of myiasis. Mechanical carrier of bacterial dysentery.
Common household and bazaar fly. Often settles around eyes of children, feeding on eye discharge.	Limited to warm season where there is a marked cool season.	Eggs deposited on or near infected part of human body, or on food later eaten by man.	Agent of importance in intestinal and eye infections. A possible infector of yaws.
Feed on cattle when present--turn to man as alternative. Generally inactive during day--but may bite at any time. Often rest in houses behind pictures, clothing or in dark corners of rooms. Ankles are a favorite point of attack.	Seasonality not known in this area.	Infects by biting man and depositing parasite in skin, or more likely by crushing infected insect on skin. Bite is quite painful.	Chief carrier of kala azar (Leishmania donovani).
Common in and around households.	Not known.	Infect by depositing larvae in food eaten by man.	Infector of intestinal myiasis of minor importance.
Common around human settlements.	Not known.	Infect by directly depositing larvae on diseased tissue, or by infecting human food.	Associated with dermal myiasis. Also reported for intestinal myiasis.
Readily attack man in lieu of natural host. In houses at higher elevations.	Not known.	Infects by biting man after being infected by host carrier.	Plague carrier. One of chief agents for maintaining plague in nature. Possibly infector for murine typhus.
Feeds voraciously on man. Follow human distribution pattern - known as the human flea. Rest by day in rugs, bedding, cracks of floors, etc.	No apparent seasonality.	Infects by biting.	Likely a plague carrier wherever abundant. Naturally infected with typhus.

TABLE III: HARMFUL INSECTS (OTHER THAN MOSQUITOES) IN SOUTHEAST ASIA (Cont'd)

Species	General Distribution	Breeding Situation and/or Environmental Adaptation	Elevations Found
Xenopsylla astia Rothschild flea	General	Parasitic on vertebrate hos . Chief hosts are Rattus rattus, Rattus concolor, and Rattus norvegicus. Found in all situations attracting rats such as grain stores, warehouses, ports, and ships. Most numerous along communications lines. More frequent on ground floor levels in closely spaced housing.	Most outbreaks in lowland sites, likely not due to fact that elevation in itself is limiting factor.
Xenopsylla cheopis (Rothschild) flea	Ceneral	Parasitic on vertebrate host. Major infestations associated with rats. Chief carriers include Rattus rattus, Rattus concolor, and Rattus norvegicus. Found in all situations attractive to rats. Infestations appear to follow river and rail connections. Host anima' ist have easy communications with outside.	Most major outbreak: associated with grain stores, ships, and ports, and most of these at low elevations. Probably not a limiting factor.
Pediculus humanus corporis Linnaeus common body louse	Found almost everywhere man found.	Inhabit man's underclothing, seek body only to feed. Eggs deposited in clothing, not on bedding. Neck and armpits common sites. Thrive under conditions of human misery, crowding, lack of fuel and poor bathing facilities. Human blood the only food. Not a serious pest in Southeast Asia because of prevailingly warm climatic conditions.	Extremely broad.
Paederus alternans Walker beetle	Noted in Indochina, especially Tonkin Basin and Laos.	Found on borders of partly flooded rice fields; on grassy borders of ponds.	Not known.
Paederus fuscipes Curtis beetle	Same.	Breed along edges of pools or partly flooded rice fields; under grass and low bush vegetation on sloping river banks.	Not known.

Affinity to Man	Seasonality of Occurrence	Means of Transmission	Role as Disease Carrier
Affinity of carrier to man affects relationship of flea to man. Towns and cities most affected.	Highest incidence during dry season. Peak from March through June in South Asia.	Depends in part on temperature and humidity, and impact of these on body moisture. Appear to infest man more during dry season.	Carrier of secondary importance of bubonic and murine plague. Suggested vector of typhus.
Relates to affinity of carriers to man, and rats generally attracted to human habitations. Towns and cities report highest incidence. Ground level locations preferred.	Highest incidence during dry season in Burma. Most active Feb-May in Indochina.	Transfer from rats to man depends partly on humidity. Animal mortality in infected animals is high, favoring a transfer to man. Infects by biting man.	Considered chief agent in transmission of bubonic plague. Possible carrier of typhus.
Found only on or near man. Man the only host for epidemic typhus.	More widespread in cool season when more clothing.	By biting infected host, or more likely by infections through contact of feces with skin abrasion, or by inhaling dried feces of lice.	Carrier of epidemic typhus, and possibly of relapsing fever.
Enters houses. Attracted by artificial light.	Found entire season on borders of partly flooded rice fields.	Blisters caused by body fluids when beetles crushed on skin.	Skin vesicant. Generally not a serious reaction, limit to epidermis.
Enter houses in May and September. Occur throughout year. Attracted by artificial light.	Not known.	Same.	Same.

TABLE IV: HARMFUL ARTHROPODS (OTHER THAN INSECTS) IN SOUTHEAST ASIA

Species	General Distribution	Breeding Situation and/or Environmental Adaptation	Elevations Found
Haemaphysalis spinigera Neumann tic	Indochina	Common in rich evergreen forest cover, heavy undergrowth. Rainfall average in excess of 80 in. where tick is commonly found. Natural hosts are monkeys, rats, squirrels, and man	Elevations in India range between 1,800 and 2,000 feet.
Rhipicephalus sanguineus (Latreille) brown dog tick	General	Females can mate only after blood meal. Eggs deposited on ground. Larvae attaches to host — dog or man. Dog principal host. Attacks man more often under hot, dry conditions.	Not known. Likely broad range.
Liponyssus bacoti Hirst mite	General	Parasitic on rats. Often turn to man after rat hosts eliminated by poisoning or trapping. Common in areas of natural rat harborage. Requires four blood meals to complete life cycle.	Broad range. Follow pattern of rat infestations.
Trombicula akamushi (Brumpt) mite	General	Most common hosts are Rattus flavipectus yunnanensis and a tree shrew, Tupaia belangeri versura Eggs laid on ground and hatched larvae attach themselves to animals frequenting area. Man occasionally an accidental host. Parasitic only in first stage after hatching. Prefer river edges in land periodically flooded.	Broad range - up to 8,000 feet.
Trombicula deliensis Walch mite	General	Most common hosts are Yunnan buff-breasted rat (Rattus flavipectus yunnanensis) and Slader's roof rat (Rattus rattus sladeni). Most commonly found in the rural situations favoring a concentration of rats such as village garden sites, abandoned food dumps, neglected coconut plantations, and heavy savanna grasslands. Scrub typhus outbreaks accompany drought, flood, poor crops, famines, filth, over-crowding, and military operations. Hosts apart from rats are often tree shrews, birds and man. Prefer river edges in land that is periodically flooded.	Greatest exposure just above sea level. T. deliensis reported up to 8,000 feet. Infections from them to 7,000 feet. Quite abundant in northern uplands of Burma.
Scolopendra cingulata centipede	Indochina and other likely areas.	Eggs laid during cooler season. Deposited in burrows in soft rotted wood. Adults often found under stoves, bark, under matting in unfloored houses. Occupy dark, damp places. Distinct preferences for high humidities. Most abundant in wet forest situation. Often found in warehouses in port cities.	Broad elevational range.
Otostigmus aculeatus Haase millipede	Indochinese area	Occupies dark crevices. Burrows under rocks, logs, mats, etc. Nocturnal activity.	Not known.

Affinity to Man	Seasonality of Occurrence	Means of Transmission	Role as Disease Carrier
Ticks infect men operating in forest.	Rare during wet monsoon. Peak months are March and April.	Transmission of disease by biting. Commonly transmitted from animal to man.	Carrier of Kyasanur Forest disease.
Man commonly attacked because of close relationship between man and dog.	Most pronounced at beginning of rainy season.	Pathogen multiplies in tick. Man innoculated by bite of tick.	Important carrier of tick borne typhus, Indian tick typhus, and other rickettsial fevers. Possibly tick paralysis.
Parasitic on house infesting rodents and may attack man.	No known seasonality. Other mites have lower incidence during dry season.	By biting man. Parasitic on rats and mice infesting houses.	Possible transmitter of murine typhus. Bite produces vesicular dermatitis. May be intermediate host for microbe carriers of tularemia.
Follow generally the pattern of rat population. Highest incidence wherever food and harborage for rats are found. Often found in jungle and rainforest far removed from man. Active in early morning.	No absolute seasonality. Subsidence appears to occur in dry season. Mites sensitive to low humidity. Highest incidence at beginning and end of monsoon season.	Infect by biting. Disease carried by mites from infected host to man.	Carrier of scrub typhus (Tsutsugamushi disease) second in importance to T. deliensis.
Influence on man dependent largely upon affinity of carrier to man. As man provides harborage for rats the incidence increases. More commonly rural settings affected. Active in early morning.	No uniform seasonality of occurrence. Highest incidence in spring and autumn at beginning and end of wet monsoon. Case incidence in Burma noted to subside during dry period. Mites appear highly sensitive to lowered humidity.	Infect by biting man. Passage of mites from rats to man takes place whenever the two occupy the same area. Infections tend to follow drainage lines.	Most important carrier of scrub typhus (Tsutsugamushi disease) in Southeast Asia.
Not especially attracted to man. May bite or sting when provoked. Poisoned claws may irritate skin.	Long-lived--up to 6 or 8 years. Inactive under cool or very dry conditions.	By biting or stinging with poisoned claws.	Skin irritant (vesicular dermatitis). Bite reported on occasion to cause painful swelling with real discomfort.
Pest in houses during periods of hot weather.	Maximum occurrence in summer.	On touch emits a phosphorescent vesicant which causes a painful blister on skin.	Skin vesicant. Not a serious reaction.

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13. ABSTRACT

This study illustrates the relationships between physical and cultural environments and the presence of harmful insects and other arthropods in mainland Southeast Asia. These relationships are graphically portrayed in diagrammatic cross sections through various parts of the study area. In addition, the physical and cultural factors that contribute to the propagation and spread of harmful insects are analyzed, and there are brief descriptions of the offending species.

Of the insects that contribute most to the origin and spread of disease, the mosquito easily takes first place. The hot, humid climate of Southeast Asia and the numerous water bodies provide ideal conditions for the survival of this group of insects. Various mosquito species are known to be transmitters of malaria, dengue fever, filariasis, and Japanese B encephalitis. Other important disease-causing insects include non-biting flies, fleas, sandflies, and lice, while disease-carrying species are also found among the mites and ticks. They are responsible for the spread of a wide variety of diseases and infections, including myiasis, plague, typhus, kala azar, yaws, and bacterial dysentery.

The principal environmental types in Southeast Asia are: (1) cities and large towns; (2) villages and isolated rural settlements; (3) ricefields; (4) brackish coastal margins; (5) delta plains, coastal plains, and floodplains; (6) elevated plains, low plateaus, foothills; and (7) hills, mountains, and dissected plateaus. Each of these environments has its own complex of harmful insects. In general, the areas of lowest elevation, highest rainfall, and least population have the widest variety of harmful insects, and the areas of highest elevation, lowest rainfall, and densest population have the fewest. However, there are exceptions to this rule.

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